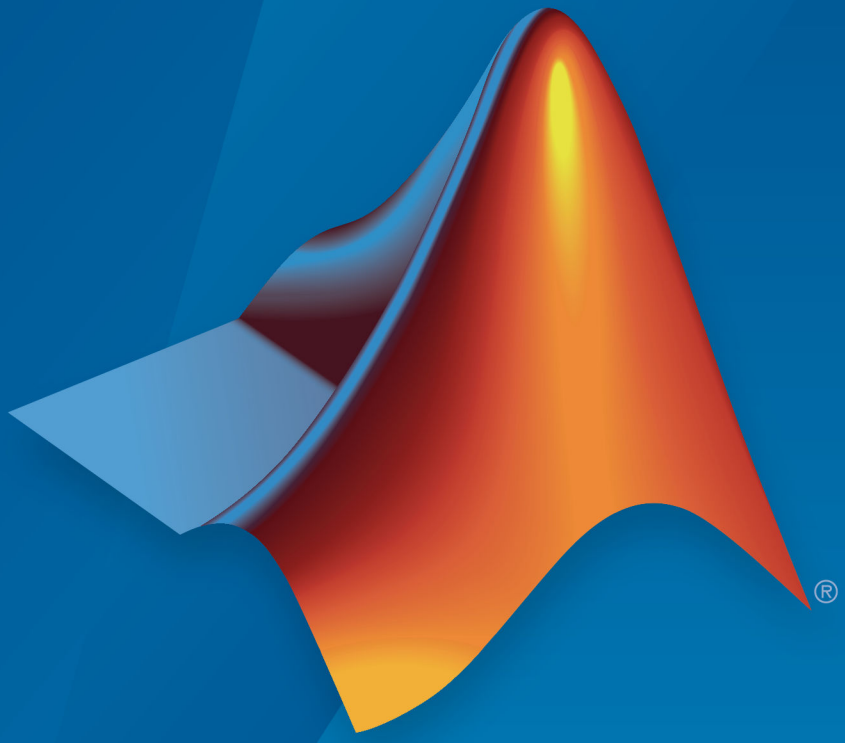
Polyspace® Bug Finder™ Access™

Reference



R2019a

MathWorks®

How to Contact MathWorks

Latest news: www.mathworks.com

Sales and services: www.mathworks.com/sales_and_services

User community: www.mathworks.com/matlabcentral

Technical support: www.mathworks.com/support/contact_us

Phone: 508-647-7000

The MathWorks, Inc.
1 Apple Hill Drive
Natick, MA 01760-2098

Polyspace® Bug Finder™ Access™ Reference

Revision History

March 2019	Online only	New for Version 2.0 (R2019a)

Contents

5 CERT C++ Rules

6 AUTOSAR C++14 Rules

7 ISO/IEC TS 17961

8 Custom Coding Rules

1

Defects

Alignment changed after memory reallocation

Memory reallocation changes the originally stricter alignment of an object

Description

Alignment changed after memory reallocation occurs when you use `realloc()` to modify the size of objects with strict memory alignment requirements.

Risk

The pointer returned by `realloc()` can be suitably assigned to objects with less strict alignment requirements. A misaligned memory allocation can lead to buffer underflow or overflow, an illegally dereferenced pointer, or access to arbitrary memory locations. In processors that support misaligned memory, the allocation impacts the performance of the system.

Fix

To reallocate memory:

1. Resize the memory block.
   - In Windows®, use `_aligned_realloc()` with the alignment argument used in `_aligned_malloc()` to allocate the original memory block.
   - In UNIX/Linux, use the same function with the same alignment argument used to allocate the original memory block.
2. Copy the original content to the new memory block.
3. Free the original memory block.

Note This fix has implementation-defined behavior. The implementation might not support the requested memory alignment and can have additional constraints for the size of the new memory.

Examples

Memory Reallocated Without Preserving the Original Alignment

```
#include <stdio.h>
#include <stdlib.h>

#define SIZE1024 1024

void func(void)
{
    size_t resize = SIZE1024;
    size_t alignment = 1 << 12; /* 4096 bytes alignment */
    int *ptr = NULL;
    int *ptr1;

    /* Allocate memory with 4096 bytes alignment */

    if (posix_memalign((void **)&ptr, alignment, sizeof(int)) != 0)
    {
        /* Handle error */
      }

    /*Reallocate memory without using the original alignment.
    ptr1 may not be 4096 bytes aligned. */

    ptr1 = (int *)realloc(ptr, sizeof(int) * resize);

    if (ptr1 == NULL)
    {
        /* Handle error */
    }

    /* Processing using ptr1 */

    /* Free before exit */
    free(ptr1);
}
```

In this example, the allocated memory is 4096-bytes aligned. `realloc()` then resizes the allocated memory. The new pointer `ptr1` might not be 4096-bytes aligned.

Correction — Specify the Alignment for the Reallocated Memory

When you reallocate the memory, use `posix_memalign()` and pass the alignment argument that you used to allocate the original memory.

```
#include <stdio.h>
#include <stdlib.h>

#define SIZE1024 1024

void func(void)
{
    size_t resize = SIZE1024;
    size_t alignment = 1 << 12; /* 4096 bytes alignment */
    int *ptr = NULL;

    /* Allocate memory with 4096 bytes alignment */
    if (posix_memalign((void **)&ptr, alignment, sizeof(int)) != 0)
    {
        /* Handle error */
    }

    /* Reallocate memory using the original alignment. */
    if (posix_memalign((void **)&ptr, alignment, sizeof(int) * resize) != 0)
    {
        /* Handle error */
        free(ptr);
        ptr = NULL;
    }

    /* Processing using ptr */

    /* Free before exit */
    free(ptr);
}
```

Result Information

Group: Dynamic memory
Language: C | C++

Default: On
Command-Line Syntax: `ALIGNMENT_CHANGE`
Impact: Low

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Assertion

Failed assertion statement

Description

Assertion occurs when you use an `assert`, and the asserted expression is or could be false.

Note Polyspace does not flag `assert(0)` as an assertion defect because these statements are commonly used to disable certain sections of code.

Risk

Typically you use `assert` statements for functional testing in debug mode. An assertion failure found using static analysis indicates that the corresponding functional test would fail at run time.

Fix

The fix depends on the root cause of the defect. For instance, the root cause can be unconstrained input from an external source that eventually led to the assertion failure.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Check Assertion on Unsigned Integer

```
#include <assert.h>

void asserting_x(unsigned int theta) {
    theta =+ 5;
    assert(theta < 0);
}
```

In this example, the `assert` function checks if the input variable, `theta`, is less than or equal to zero. The assertion fails because `theta` is an unsigned integer, so the value at the beginning of the function is at least zero. The `+=` statement increases this positive value by five. Therefore, the range of `theta` is `[5..MAX_INT]`. `theta` is always greater than zero.

Correction — Change Assert Expression

One possible correction is to change the assertion expression. By changing the *less-than-or-equal-to* sign to a *greater-than-or-equal-to* sign, the assertion does not fail.

```
#include <assert.h>

void asserting_x(unsigned int theta) {
    theta =+ 5;
    assert(theta > 0);
}
```

Correction — Fix Code

One possible correction is to fix the code related to the assertion expression. If the assertion expression is true, fix your code so the assertion passes.

```
#include <assert.h>
#include <stdlib.h>

void asserting_x(int theta) {
    theta = -abs(theta);
    assert(theta < 0);
}
```

Asserting Zero

```
#include <assert.h>

#define FLAG 0

int main(void){
    int i_test_z = 0;
    float f_test_z = (float)i_test_z;

    assert(i_test_z);
    assert(f_test_z);
    assert(FLAG);

    return 0;
}
```

In this example, Polyspace does not flag `assert(FLAG)` as a violation because a macro defines `FLAG` as `0`. The Polyspace Bug Finder assertion checker does not flag assertions with a constant zero parameter, `assert(0)`. These types of assertions are commonly used as dynamic checks during runtime. By inserting `assert(0)`, you indicate that the program must not reach this statement during run time, otherwise the program crashes.

However, the assertion checker does flag failed assertions caused by a variable value equal to zero, as seen in the example with `assert(i_test_z)` and `assert(f_test_z)`.

Check Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: ASSERT
Impact: High

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Atomic variable accessed twice in an expression

Variable can be modified between accesses

Description

Atomic variable accessed twice in an expression occurs when C atomic types or C++ `std::atomic` class variables appear twice in an expression and there are:

- Two atomic read operations on the variable.
- An atomic read and a distinct atomic write operation on the variable.

The C standard defines certain operations on atomic variables that are thread safe and do not cause data race conditions. Unlike individual operations, a pair of operations on the same atomic variable in an expression is not thread safe.

Risk

A thread can modify the atomic variable between the pair of atomic operations, which can result in a data race condition.

Fix

Do not reference an atomic variable twice in the same expression.

Examples

Referencing Atomic Variable Twice in an Expression

```
#include <stdatomic.h>

atomic_int n = ATOMIC_VAR_INIT(0);
```

```
int compute_sum(void)
{
    return n * (n + 1) / 2;
}
```

In this example, the global variable `n` is referenced twice in the return statement of `compute_sum()`. The value of `n` can change between the two distinct read operations. `compute_sum()` can return an incorrect value.

Correction — Pass Variable as Function Argument

One possible correction is to pass the variable as a function argument `n`. The variable is copied to memory and the read operations on the copy guarantee that `compute_sum()` returns a correct result. If you pass a variable of type `int` instead of type `atomic_int`, the correction is still valid.

```
#include <stdatomic.h>

int compute_sum(atomic_int n)
{
    return n * (n + 1) / 2;
}
```

Result Information

Group: Concurrency
Language: C | C++
Default: On
Command-Line Syntax: `ATOMIC_VAR_ACCESS_TWICE`
Impact: Medium

See Also

`Atomic load and store sequence not atomic` | `Data race` | `Data race including atomic operations`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

Atomic load and store sequence not atomic

Variable accessible between load and store operations

Description

Atomic load and store sequence not atomic occurs when you use these functions to load, and then store an atomic variable.

- C functions:
  - `atomic_load()`
  - `atomic_load_explicit()`
  - `atomic_store()`
  - `atomic_store_explicit()`
- C++ functions:
  - `std::atomic_load()`
  - `std::atomic_load_explicit()`
  - `std::atomic_store()`
  - `std::atomic_store_explicit()`
  - `std::atomic::load()`
  - `std::atomic::store()`

A thread cannot interrupt an atomic load or an atomic store operation on a variable, but a thread can interrupt a store, and then load sequence.

Risk

A thread can modify a variable between the load and store operations, resulting in a data race condition.

Fix

To read, modify, and store a variable atomically, use a compound assignment operator such as +=, `atomic_compare_exchange()` or `atomic_fetch_*`-family functions.

Examples

Loading Then Storing an Atomic Variable

```
#include <stdatomic.h>
#include <stdbool.h>

static atomic_bool flag = ATOMIC_VAR_INIT(false);

void init_flag(void)
{
    atomic_init(&flag, false);
}

void toggle_flag(void)
{
    bool temp_flag = atomic_load(&flag);
    temp_flag = !temp_flag;
    atomic_store(&flag, temp_flag);
}

bool get_flag(void)
{
    return atomic_load(&flag);
}
```

In this example, variable `flag` of type `atomic_bool` is referenced twice inside the `toggle_flag()` function. The function loads the variable, negates its value, then stores the new value back to the variable. If two threads call `toggle_flag()`, the second thread can access `flag` between the load and store operations of the first thread. `flag` can end up in an incorrect state.

Correction — Use Compound Assignment to Modify Variable

One possible correction is to use a compound assignment operator to toggle the value of `flag`. The C standard defines the operation by using ^= as atomic.

```
 #include <stdatomic.h>
#include <stdbool.h>

static atomic_bool flag = ATOMIC_VAR_INIT(false);

void toggle_flag(void)
{
    flag ^= 1;
}

bool get_flag(void)
{
    return flag;
}
```

Result Information

Group: Concurrency
Language: C | C++
Default: On
Command-Line Syntax: ATOMIC_VAR_SEQUENCE_NOT_ATOMIC
Impact: Medium

See Also

Atomic variable accessed twice in an expression | Data race | Data race including atomic operations

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

Invalid deletion of pointer

Pointer deallocation using `delete` without corresponding allocation using `new`

Description

Invalid deletion of pointer occurs when:

- You release a block of memory with the `delete` operator but the memory was previously not allocated with the `new` operator.
- You release a block of memory with the `delete` operator using the single-object notation but the memory was previously allocated as an array with the `new` operator.

This defect applies only to C++ source files.

Risk

The risk depends on the cause of the issue:

- The `delete` operator releases a block of memory allocated on the heap. If you try to access a location on the heap that you did not allocate previously, a segmentation fault can occur.
- If you use the single-object notation for `delete` on a pointer that is previously allocated with the array notation for `new`, the behavior is undefined.

The issue can also highlight other coding errors. For instance, you perhaps wanted to use the `delete` operator or a previous `new` operator on a different pointer.

Fix

The fix depends on the cause of the issue:

- In most cases, you can fix the issue by removing the `delete` statement. If the pointer is not allocated memory from the heap with the `new` operator, you do not need to release the pointer with `delete`. You can simply reuse the pointer as required or let the object be destroyed at the end of its scope.

- In case of mismatched notation for `new` and `delete`, correct the mismatch. For instance, to allocate and deallocate a single object, use this notation:

  ```
  classType* ptr = new classType;
  delete ptr;
  ```

  To allocate and deallocate an array objects, use this notation:

  ```
  classType* p2 = new classType[10];
  delete[] p2;
  ```

If the issue highlights a coding error such as use of `delete` or `new` on the wrong pointer, correct the error.

Examples

Deleting Static Memory

```
void assign_ones(void)
{
    int ptr[10];

    for(int i=0;i<10;i++)
        *(ptr+i)=1;

    delete[] ptr;
}
```

The pointer `ptr` is released using the `delete` operator. However, `ptr` points to a memory location that was not dynamically allocated.

Correction: Remove Pointer Deallocation

If the number of elements of the array `ptr` is known at compile time, one possible correction is to remove the deallocation of the pointer `ptr`.

```
void assign_ones(void)
{
    int ptr[10];

    for(int i=0;i<10;i++)
```

```
        *(ptr+i)=1;
}
```

Correction — Add Pointer Allocation

If the number of array elements is not known at compile time, one possible correction is to dynamically allocate memory to the array `ptr` using the `new` operator.

```
void assign_ones(int num)
{
    int *ptr = new int[num];

    for(int i=0; i < num; i++)
        *(ptr+i) = 1;

    delete[] ptr;
   }
```

Mismatched `new` and `delete`

```
int main (void)
{
    int *p_scale = new int[5];

    //more code using scal

    delete p_scale;
}
```

In this example, `p_scale` is initialized to an array of size 5 using `new int[5]`. However, `p_scale` is deleted with `delete` instead of `delete[]`. The `new`-`delete` pair does not match. Do not use `delete` without the brackets when deleting arrays.

Correction — Match `delete` to `new`

One possible correction is to add brackets so the `delete` matches the `new []` declaration.

```
int main (void)
{
    int *p_scale = new int[5];

    //more code using p_scale
```

```
    delete[] p_scale;
}
```

Correction — Match `new` to `delete`

Another possible correction is to change the declaration of `p_scale`. If you meant to initialize `p_scale` as 5 itself instead of an array of size 5, you must use different syntax. For this correction, change the square brackets in the initialization to parentheses. Leave the `delete` statement as it is.

```
int main (void)
{
    int *p_scale = new int(5);

    //more code using p_scale

    delete p_scale;
}
```

Check Information

Group: Dynamic memory
Language: C++
Default: Off
Command-Line Syntax: `BAD_DELETE`
Impact: High
CWE ID: 404

See Also

`Invalid free of pointer` | `Memory leak`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Invalid use of == operator

Equality operation in assignment statement

Description

Invalid use of == operator occurs when you use an equality operator instead of an assignment operator in a simple statement.

Risk

The use of == operator instead of an = operator can silently produce incorrect results. If you intended to assign a value to a variable, the assignment does not occur. The variable retains its previous value or if not initialized previously, stays uninitialized.

Fix

Use the = (assignment) operator instead of the == (equality) operator.

The check appears on chained assignment and equality operators such as:

```
compFlag = val1 == val2;
```

For better readability of your code, place the equality check in parenthesis.

```
compFlag = (val1 == val2);
```

If the use of == operator is intended, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Equality Evaluation in `for`-Loop

```
void populate_array(void)
{
```

```
    int i = 0;
    int j = 0;
    int array[4];

    for (j == 5; j < 9; j++) {
        array[i] = j;
        i++;
    }
}
```

Inside the `for`-loop, the statement `j == 5` tests whether `j` is equal to 5 instead of setting `j` to 5. The `for`-loop iterates from 0 to 8 because `j` starts with a value of 0, not 5. A by-product of the invalid equality operator is an out-of-bounds array access in the next line.

Correction — Change to Assignment Operator

One possible correction is to change the == operator to a single equal sign (=). Changing the == sign resolves both defects because the `for`-loop iterates the intended number of times.

```
void populate_array(void)
{
    int i = 0;
    int j = 0;
    int array[4];

    for (j = 5; j < 9; j++) {
        array[i] = j;
        i++;
    }
}
```

Check Information

Group: Programming
Language: C | C++
Default: On for handwritten code, off for generated code
Command-Line Syntax: `BAD_EQUAL_EQUAL_USE`
Impact: High
CWE ID: 480, 482

See Also

`Invalid use of = (assignment) operator`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Invalid use of = operator

Assignment in conditional statement

Description

Invalid use of = operator occurs when an assignment is made inside the predicate of a conditional, such as `if` or `while`.

In C and C++, a single equal sign is an assignment not a comparison. Using a single equal sign in a conditional statement can indicate a typo or a mistake.

Risk

- Conditional statement tests the wrong values— The single equal sign operation assigns the value of the right operand to the left operand. Then, because this assignment is inside the predicate of a conditional, the program checks whether the new value of the left operand is nonzero or not NULL.
- Maintenance and readability issues — Even if the assignment is intended, someone reading or updating the code can misinterpret the assignment as an equality comparison instead of an assignment.

Fix

- If the assignment is a bug, to check for equality, add a second equal sign (==).
- If the assignment inside the conditional statement was intentional, to improve readability, separate the assignment and the test. Move the assignment outside the control statement. In the control statement, simply test the result of the assignment.

  If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Single Equal Sign Inside an `if` Condition

```
#include <stdio.h>

void bad_equals_ex(int alpha, int beta)
{
    if(alpha = beta)
    {
        printf("Equal\n");
    }
}
```

The equal sign is flagged as a defect because the assignment operator is used within the predicate of the if-statement. The predicate assigns the value `beta` to `alpha`, then implicitly tests whether `alpha` is true or false.

Correction — Change Expression to Comparison

One possible correction is adding an additional equal sign. This correction changes the assignment to a comparison. The if condition compares whether `alpha` and `beta` are equal.

```
#include <stdio.h>

void equality_test(int alpha, int beta)
{
    if(alpha == beta)
    {
        printf("Equal\n");
    }
}
```

Correction — Assignment and Comparison Inside the `if` Condition

If an assignment must be made inside the predicate, a possible correction is adding an explicit comparison. This correction assigns the value of `beta` to `alpha`, then explicitly checks whether `alpha` is nonzero. The code is clearer.

```
#include <stdio.h>

int assignment_not_zero(int alpha, int beta)
```

```
{
    if((alpha = beta) != 0)
    {
        return alpha;
    }
    else
    {
        return 0;
    }
}
```

Correction — Move Assignment Outside the `if` Statement

If the assignment can be made outside the control statement, one possible correction is to separate the assignment and comparison. This correction assigns the value of `beta` to `alpha` before the if. Inside the if-condition, only `alpha` is given to test if `alpha` is nonzero or not NULL.

```
#include <stdio.h>

void assign_and_print(int alpha, int beta)
{
    alpha = beta;
    if(alpha)
    {
        printf("%d", alpha);
    }
}
```

Check Information

Group: Programming
Language: C | C++
Default: On for handwritten code, off for generated code
Command-Line Syntax: `BAD_EQUAL_USE`
Impact: Medium
CWE ID: 480, 481

See Also

`Invalid use of == (equality) operator`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Bad file access mode or status

Access mode argument of function in `fopen` or `open` group is invalid

Description

Bad file access mode or status occurs when you use functions in the `fopen` or `open` group with invalid or incompatible file access modes, file creation flags, or file status flags as arguments. For instance, for the `open` function, examples of valid:

- Access modes include `O_RDONLY`, `O_WRONLY`, and `O_RDWR`
- File creation flags include `O_CREAT`, `O_EXCL`, `O_NOCTTY`, and `O_TRUNC`.
- File status flags include `O_APPEND`, `O_ASYNC`, `O_CLOEXEC`, `O_DIRECT`, `O_DIRECTORY`, `O_LARGEFILE`, `O_NOATIME`, `O_NOFOLLOW`, `O_NONBLOCK`, `O_NDELAY`, `O_SHLOCK`, `O_EXLOCK`, `O_FSYNC`, `O_SYNC` and so on.

The defect can occur in the following situations.

Situation	Risk	Fix
You pass an empty or invalid access mode to the `fopen` function. According to the ANSI® C standard, the valid access modes for `fopen` are: • `r`,`r+` • `w`,`w+` • `a`,`a+` • `rb`, `wb`, `ab` • `r+b`, `w+b`, `a+b` • `rb+`, `wb+`, `ab+`	`fopen` has undefined behavior for invalid access modes. Some implementations allow extension of the access mode such as: • GNU®: `rb +cmxe,ccs=utf` • Visual C++®: `a+t`, where `t` specifies a text mode. However, your access mode string must begin with one of the valid sequences.	Pass a valid access mode to `fopen`.

Situation	Risk	Fix
You pass the status flag `O_APPEND` to the `open` function without combining it with either `O_WRONLY` or `O_RDWR`.	`O_APPEND` indicates that you intend to add new content at the end of a file. However, without `O_WRONLY` or `O_RDWR`, you cannot write to the file. The `open` function does not return -1 for this logical error.	Pass either `O_APPEND|O_WRONLY` or `O_APPEND|O_RDWR` as access mode.
You pass the status flags `O_APPEND` and `O_TRUNC` together to the `open` function.	`O_APPEND` indicates that you intend to add new content at the end of a file. However, `O_TRUNC` indicates that you intend to truncate the file to zero. Therefore, the two modes cannot operate together. The `open` function does not return -1 for this logical error.	Depending on what you intend to do, pass one of the two modes.
You pass the status flag `O_ASYNC` to the `open` function.	On certain implementations, the mode `O_ASYNC` does not enable signal-driven I/O operations.	Use the `fcntl(pathname, F_SETFL, O_ASYNC);` instead.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Invalid Access Mode with `fopen`

```
#include <stdio.h>

void func(void) {
    FILE *file = fopen("data.txt", "rw");
    if(file!=NULL) {
        fputs("new data",file);
        fclose(file);
    }
}
```

In this example, the access mode `rw` is invalid. Because `r` indicates that you open the file for reading and `w` indicates that you create a new file for writing, the two access modes are incompatible.

Correction — Use Either `r` or `w` as Access Mode

One possible correction is to use the access mode corresponding to what you intend to do.

```
#include <stdio.h>

void func(void) {
    FILE *file = fopen("data.txt", "w");
    if(file!=NULL) {
        fputs("new data",file);
        fclose(file);
    }
}
```

Result Information

Group: Programming
Language: C | C++
Default: Off

Command-Line Syntax: `BAD_FILE_ACCESS_MODE_STATUS`
Impact: Medium
CWE ID: 628, 686

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Floating point comparison with equality operators

Imprecise comparison of floating-point variables

Description

Floating point comparison with equality operators occurs when you use an equality (==) or inequality (!=) operation with floating-point numbers.

Polyspace does not raise a defect for an equality or inequality operation with floating-point numbers when:

- The comparison is between two float constants.

  ```
  float flt = 1.0;
  if (flt == 1.1)
  ```

- The comparison is between a constant and a variable that can take a finite, reasonably small number of values.

  ```
  float x;

  int rand = random();
  switch(rand) {
  case 1: x = 0.0; break;
  case 2: x = 1.3; break;
  case 3: x = 1.7; break;
  case 4: x = 2.0; break;
  default: x = 3.5; break; }
  …
  if (x==1.3)
  ```

- The comparison is between floating-point expressions that contain only integer values.

  ```
  float x = 0.0;
  for (x=0.0;x!=100.0;x+=1.0) {
  …
  if (random) break;
  }
  ```

```
if (3*x+4==2*x-1)
…
if (3*x+4 == 1.3)
```

- One of the operands is `0.0`, unless you use the option flag `-detect-bad-float-op-on-zero`.

  ```
  /* Defect detected when
  you use the option flag */

  if (x==0.0f)
  ```

  If you are running an analysis through the user interface, you can enter this option in the **Other** field, under the **Advanced Settings** node on the **Configuration** pane. See `Other`. For more information on this analysis option, see the documentation for Polyspace Bug Finder.

  At the command line, add the flag to your analysis command.

  ```
  polyspace-bug-finder -sources filename ^
  -checkers BAD_FLOAT_OP -detect-bad-float-op-on-zero
  ```

Risk

Checking for equality or inequality of two floating-point values might return unexpected results because floating-point representations are inexact and involve rounding errors.

Fix

Instead of checking for equality of floating-point values:

```
if (val1 == val2)
```

check if their difference is less than a predefined tolerance value (for instance, the value `FLT_EPSILON` defined in `float.h`):

```
#include <float.h>
if(fabs(val1-val2) < FLT_EPSILON)
```

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Floats Inequality in `for`-loop

```
#include <stdio.h>
#include <math.h>
#include <float.h>

void func(void)
{
    float f;
    for (f = 1.0; f != 2.0; f = f + 0.1)
        (void)printf("Value: %f\n", f);
}
```

In this function, the `for`-loop tests the inequality of `f` and the number 2.0 as a stopping mechanism. The number of iterations is difficult to determine, or might be infinite, because of the imprecision in floating-point representation.

Correction — Change the Operator

One possible correction is to use a different operator that is not as strict. For example, an inequality like >= or <=.

```
#include <stdio.h>
#include <math.h>
#include <float.h>

void func(void)
{
    float f;
    for (f = 1.0; f <= 2.0; f = f + 0.1)
        (void)printf("Value: %f\n", f);
}
```

Check Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: `BAD_FLOAT_OP`

Impact: Medium
CWE ID: 873

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Invalid free of pointer

Pointer deallocation without a corresponding dynamic allocation

Description

Invalid free of pointer occurs when a block of memory released using the `free` function was not previously allocated using `malloc`, `calloc`, or `realloc`.

Risk

The `free` function releases a block of memory allocated on the heap. If you try to access a location on the heap that you did not allocate previously, a segmentation fault can occur.

The issue can highlight coding errors. For instance, you perhaps wanted to use the `free` function or a previous `malloc` function on a different pointer.

Fix

In most cases, you can fix the issue by removing the `free` statement. If the pointer is not allocated memory from the heap with `malloc` or `calloc`, you do not need to free the pointer. You can simply reuse the pointer as required.

If the issue highlights a coding error such as use of `free` or `malloc` on the wrong pointer, correct the error.

If the issue occurs because you use the `free` function to free memory allocated with the `new` operator, replace the `free` function with the `delete` operator.

Examples

Invalid Free of Pointer Error

```
#include <stdlib.h>
```

```
void Assign_Ones(void)
{
  int p[10];
  for(int i=0;i<10;i++)
     *(p+i)=1;

  free(p);
  /* Defect: p does not point to dynamically allocated memory */
}
```

The pointer `p` is deallocated using the `free` function. However, `p` points to a memory location that was not dynamically allocated.

Correction — Remove Pointer Deallocation

If the number of elements of the array `p` is known at compile time, one possible correction is to remove the deallocation of the pointer `p`.

```
#include <stdlib.h>

void Assign_Ones(void)
 {
  int p[10];
  for(int i=0;i<10;i++)
     *(p+i)=1;
  /* Fix: Remove deallocation of p */
 }
```

Correction — Introduce Pointer Allocation

If the number of elements of the array `p` is not known at compile time, one possible correction is to dynamically allocate memory to the array `p`.

```
#include <stdlib.h>

void Assign_Ones(int num)
{
  int *p;
  /* Fix: Allocate memory dynamically to p */
  p=(int*) calloc(10,sizeof(int));
  for(int i=0;i<10;i++)
     *(p+i)=1;
  free(p);
}
```

Check Information

Group: Dynamic Memory
Language: C | C++
Default: On
Command-Line Syntax: `BAD_FREE`
Impact: High
CWE ID: 404, 590, 762

See Also

`Invalid deletion of pointer`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Unsafe conversion between pointer and integer

Misaligned or invalid results from conversions between pointer and integer types

Description

Unsafe conversion between pointer and integer checks for pointer to integer and integer to pointers conversions. If you convert between a pointer, `intptr_t`, or `uintprt_t` and an integer type, such as `enum`, `ptrdiff_t`, or `pid_t`, Polyspace raises a defect.

Risk

The mapping between pointers and integers is not always consistent with the addressing structure of the environment.

Converting from pointers to integers can create:

- Truncated or out of range integer values.
- Invalid integer types.

Converting from integers to pointers can create:

- Misaligned pointers or misaligned objects.
- Invalid pointer addresses.

Fix

Where possible, avoid pointer-to-integer or integer-to-pointer conversions. If you want to convert a `void` pointer to an integer, so that you do not change the value, use types:

- C99 — `intptr_t` or `uintptr_t`
- C90 — `size_t` or `ssize_t`

Examples

Integer to Pointer Conversions

```
unsigned int *badintptrcast(void)
{
    unsigned int *ptr0 = (unsigned int *)0xdeadbeef;
    char *ptr1 = (char *)0xdeadbeef;
    return (unsigned int *)(ptr0 - (unsigned int *)ptr1);
}
```

In this example, there are three conversions, two unsafe conversions and one safe conversion. The first conversion of `0xdeadbeef` to `unsigned int*` causes alignment issues for the pointer. The second conversion of `0xdeadbeef` to `char *` is safe because there are no alignment issues for `char`. The third conversion in the return casts `ptrdiff_t` to a pointer. This pointer might or might not point to an invalid address.

Correction — Use `intptr_t`

One possible correction is to use `intptr_t` types to store the pointer address `0xdeadbeef`. Also, you can change the second pointer to an integer offset so that there is no longer a conversion from `ptrdiff_t` to a pointer.

```
#include <stdint.h>

unsigned int *badintptrcast(void)
{
    intptr_t iptr0 = (intptr_t)0xdeadbeef;
    int offset = 0;
    return (unsigned int *)(iptr0 - offset);
}
```

Result Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: `BAD_INT_PTR_CAST`
Impact: Medium
CWE ID: 465, 466, 587, 758

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2016b

Missing unlock

Lock function without unlock function

Description

Missing unlock occurs when:

- A task calls a lock function.
- The task ends without a call to an unlock function.

In multitasking code, a lock function begins a critical section of code and an unlock function ends it. When a task, `my_task`, calls a lock function, `my_lock`, other tasks calling `my_lock` must wait until `my_task` calls the corresponding unlock function. Polyspace requires that both lock and unlock functions must have the form `void func(void)`.

To find this defect, before analysis, you must specify the multitasking options. On the **Configuration** pane, select **Multitasking**.

Risk

An unlock function ends a critical section so that other waiting tasks can enter the critical section. A missing unlock function can result in tasks blocked for an unnecessary length of time.

Fix

Identify the critical section of code, that is, the section that you want to be executed as an atomic block. At the end of this section, call the unlock function that corresponds to the lock function used at the beginning of the section.

There can be other reasons and corresponding fixes for the defect. Perhaps you called the incorrect unlock function. Check the lock-unlock function pair in your Polyspace analysis configuration and fix the mismatch.

See examples of fixes below. To avoid the issue, you can follow the practice of calling the lock and unlock functions in the same module at the same level of abstraction. For

instance, in this example, `func` calls the lock and unlock function at the same level but `func2` does not.

```
void func() {
  my_lock();
  {
    ...
  }
  my_unlock();
}

void func2() {
  {
   my_lock();
   ...
  }
  my_unlock();
}
```

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Missing Unlock

```
void begin_critical_section(void);
void end_critical_section(void);

int global_var;

void reset()
{
    begin_critical_section();
    global_var = 0;
    end_critical_section();
}

void my_task(void)
```

```
{
    begin_critical_section();
    global_var += 1;
}
```

In this example, to emulate multitasking behavior, specify the following options:

Option	Value	
Configure multitasking manually	☑	
Tasks (-entry-points)	my_task, reset	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section	end_critical_section

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
   -entry-points my_task,reset
   -critical-section-begin begin_critical_section:cs1
   -critical-section-end end_critical_section:cs1
```

The example has two entry points, `my_task` and `reset`. `my_task` enters a critical section through the call `begin_critical_section();`. `my_task` ends without calling `end_critical_section`.

Correction — Provide Unlock

One possible correction is to call the unlock function `end_critical_section` after the instructions in the critical section.

```
void begin_critical_section(void);
void end_critical_section(void);
```

```
int global_var;

void reset(void)
{
    begin_critical_section();
    global_var = 0;
    end_critical_section();
}

void my_task(void)
{
    begin_critical_section();
    global_var += 1;
    end_critical_section();
}
```

Unlock in Condition

```
void begin_critical_section(void);
void end_critical_section(void);

int global_var;

void reset() {
    begin_critical_section();
    global_var=0;
    end_critical_section();
}

void my_task(void) {
    int index=0;
    volatile int numCycles;

    while(numCycles) {
      begin_critical_section();
      global_var ++;
      if(index%10==0) {
        global_var = 0;
        end_critical_section();
      }
      index++;
```

```
    }
}
```

In this example, to emulate multitasking behavior, specify the following options.

Option	Specification	
`Configure multitasking manually`	☑	
`Tasks (-entry-points)`	`my_task`, `reset`	
`Critical section details (-critical-section-begin -critical-section-end)`	**Starting routine**	**Ending routine**
	`begin_critical_section`	`end_critical_section`

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
   -entry-points my_task,reset
   -critical-section-begin begin_critical_section:cs1
   -critical-section-end end_critical_section:cs1
```

The example has two entry points, `my_task` and `reset`.

In the `while` loop, `my_task` enters a critical section through the call `begin_critical_section();`. In an iteration of the `while` loop:

- If `my_task` enters the `if` condition branch, the critical section ends through a call to `end_critical_section`.
- If `my_task` does not enter the `if` condition branch and leaves the `while` loop, the critical section does not end. Therefore, a **Missing unlock** defect occurs.
- If `my_task` does not enter the `if` condition branch and continues to the next iteration of the `while` loop, the lock function `begin_critical_section` is called again. A **Double lock** defect occurs.

Because `numCycles` is a `volatile` variable, it can take any value. Any of the cases above is possible. Therefore, a **Missing unlock** defect and a **Double lock** defect appear on the call `begin_critical_section`.

Correction — Place Unlock Outside Condition

One possible correction is to call the unlock function `end_critical_section` outside the `if` condition.

```
void begin_critical_section(void);
void end_critical_section(void);

int global_var;

void reset() {
    begin_critical_section();
    global_var=0;
    end_critical_section();
}

void my_task(void) {
    int index=0;
    volatile int numCycles;

    while(numCycles) {
      begin_critical_section();
      global_var ++;
      if(index%10==0) {
        global_var=0;
      }
      end_critical_section();
      index++;
    }
}
```

Correction — Place Unlock in Every Conditional Branch

Another possible correction is to call the unlock function `end_critical_section` in every branches of the `if` condition.

```
void begin_critical_section(void);
void end_critical_section(void);
```

```
int global_var;

void reset() {
    begin_critical_section();
    global_var=0;
    end_critical_section();
}

void my_task(void) {
    int index=0;
    volatile int numCycles;

    while(numCycles) {
      begin_critical_section();
      global_var ++;
      if(index%10==0) {
        global_var=0;
        end_critical_section();
      }
      else
        end_critical_section();
      index++;
    }
}
```

Check Information

Group: Concurrency
Language: C | C++
Default: On
Command-Line Syntax: BAD_LOCK
Impact: High
CWE ID: 667

See Also

Data race | Data race including atomic operations | Data race through standard library function call | Deadlock | Destruction of locked mutex | Double lock | Double unlock | Missing lock

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2014b

Incorrect order of network connection operations

Socket is not correctly established due to bad order of connection steps or missing steps

Description

Incorrect order of network connection operations occurs when you perform operations on a network connection at the wrong point of the connection lifecycle.

Risk

Sending or receiving data to an incorrectly connected socket can cause unexpected behavior or disclosure of sensitive information.

If you do not connect your socket correctly or change the connection by mistake, you can send sensitive data to an unexpected port. You can also get unexpected data from an incorrect socket.

Fix

During socket connection and communication, check the return of each call and the length of the data.

Before reading, writing, sending, or receiving information, create sockets in this order:

- For a connection-oriented server socket (`SOCK_STREAM` or `SOCK_SEQPACKET`):

  ```
  socket(...);
  bind(...);
  listen(...);
  accept(...);
  ```

- For a connectionless server socket (`SOCK_DGRAM`):

  ```
  socket(...);
  bind(...);
  ```

- For a client socket (connection-oriented or connectionless):

```
socket(...);
connect(...);
```

Examples

Connecting a Connection-Oriented Server Socket

```
# include <stdio.h>
# include <string.h>
# include <time.h>
# include <arpa/inet.h>
# include <unistd.h>

enum { BUF_SIZE=1025 };

volatile int rd;

int stream_socket_server(int argc, char *argv[])
{
    int listenfd = 0, connfd = 0;
    struct sockaddr_in serv_addr;

    char sendBuff[BUF_SIZE];
    time_t ticks;
    struct tm * timeinfo;

    listenfd = socket(AF_INET, SOCK_STREAM, 0);
    memset(&serv_addr, 48, sizeof(serv_addr));
    memset(sendBuff, 48, sizeof(sendBuff));

    serv_addr.sin_family = AF_INET;
    serv_addr.sin_addr.s_addr = htonl(INADDR_ANY);
    serv_addr.sin_port = htons(5000);

    bind(listenfd, (struct sockaddr*)&serv_addr, sizeof(serv_addr));

    listen(listenfd, 10);

    while(1)
    {
```

```
        connfd = accept(listenfd, (struct sockaddr*)NULL, NULL);

        ticks = time(NULL);
        timeinfo = localtime(&ticks);
        strftime (sendBuff,BUF_SIZE,"%I:%M%p.",timeinfo);

        write(listenfd, sendBuff, strlen(sendBuff));

        close(connfd);
        sleep(1);
    }
}
```

This example creates a connection-oriented network connection. The function calls the correct functions in the correct order: `socket`, `bind`, `listen`, `accept`. However, the program should write to the `connfd` socket instead of the `listenfd` socket.

Correction — Use Safe Socket

One possible correction is to write to the `connfd` function instead of the `listenfd` socket.

```
# include <stdio.h>
# include <string.h>
# include <time.h>
# include <arpa/inet.h>
# include <unistd.h>

enum { BUF_SIZE=1025 };

volatile int rd;

int stream_socket_server_good(int argc, char *argv[])
{
    int listenfd = 0, connfd = 0;
    struct sockaddr_in serv_addr;

    char sendBuff[BUF_SIZE];
    time_t ticks;
    struct tm * timeinfo;

    listenfd = socket(AF_INET, SOCK_STREAM, 0);
    memset(&serv_addr, 48, sizeof(serv_addr));
    memset(sendBuff, 48, sizeof(sendBuff));
```

```
    serv_addr.sin_family = AF_INET;
    serv_addr.sin_addr.s_addr = htonl(INADDR_ANY);
    serv_addr.sin_port = htons(5000);

    bind(listenfd, (struct sockaddr*)&serv_addr, sizeof(serv_addr));
    listen(listenfd, 10);

    while(1)
    {
        connfd = accept(listenfd, (struct sockaddr*)NULL, NULL);
        ticks = time(NULL);
        timeinfo = localtime(&ticks);
        strftime (sendBuff,BUF_SIZE,"%I:%M%p.",timeinfo);
        write(connfd, sendBuff, strlen(sendBuff));
        close(connfd);
        sleep(1);
    }
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `BAD_NETWORK_CONNECT_ORDER`
Impact: Medium
CWE ID: 666

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Use of plain char type for numerical value

Plain `char` variable in arithmetic operation without explicit signedness

Description

Use of plain char type for numerical value detects `char` variables without explicit signedness that are being used in these ways:

- To store non-char constants
- In an arithmetic operation when the `char` is:
  - A negative value.
  - The result of a sign changing overflow.
- As a buffer offset.

`char` variables without a `signed` or `unsigned` qualifier can be either signed or unsigned depending on your compiler.

Risk

Operations on a plain char can result in unexpected numerical values. If the char is used as an offset, the char can cause buffer overflow or underflow.

Fix

When initializing a char variable, to avoid implementation-defined confusion, explicitly state whether the char is signed or unsigned.

Examples

Divide by `char` Variable

```
#include <stdio.h>
```

```
void badplaincharuse(void)
{
    char c = 200;
    int i = 1000;
    (void)printf("i/c = %d\n", i/c);
}
```

In this example, the char variable `c` can be signed or unsigned depending on your compiler. Assuming 8-bit, two's complement character types, the result is either `i/c = 5` (unsigned char) or `i/c = -17` (signed char). The correct result is unknown without knowing the signedness of `char`.

Correction — Add `signed` Qualifier

One possible correction is to add a `signed` qualifier to `char`. This clarification makes the operation defined.

```
#include <stdio.h>

void badplaincharuse(void)
{
    signed char c = -56;
    int i = 1000;
    (void)printf("i/c = %d\n", i/c);
}
```

Result Information

Group: Numerical
Language: C | C++
Default: Off
Command-Line Syntax: `BAD_PLAIN_CHAR_USE`
Impact: Medium
CWE ID: 682, 758

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2016b

Bad order of dropping privileges

Dropped higher elevated privileges before dropping lower elevated privileges

Description

Bad order of dropping privileges checks the order of privilege drops. If you drop higher elevated privileges before dropping lower elevated privileges, Polyspace raises a defect. For example dropping elevated primary group privileges before dropping elevated ancillary group privileges.

Risk

If you drop privileges in the wrong order, you can potentially drop higher privileges that you need to drop lower privileges. The incorrect order can mean, privileges are not dropped, compromising the security of your program.

Fix

Respect this order of dropping elevated privileges:

- Drop (elevated) ancillary group privileges, then drop (elevated) primary group privileges.
- Drop (elevated) primary group privileges, then drop (elevated) user privileges.

Examples

Dropping User Privileges First

```
#define _BSD_SOURCE
#include <sys/types.h>
#include <unistd.h>
#include <grp.h>
#include <stdlib.h>
#define fatal_error() abort()
```

```
static void sanitize_privilege_drop_check(uid_t olduid, gid_t oldgid)
{
    if (seteuid(olduid) != -1)
    {
        /* Privileges can be restored, handle error */
        fatal_error();
    }
    if (setegid(oldgid) != -1)
    {
        /* Privileges can be restored, handle error */
        fatal_error();
    }
}
void badprivilegedroporder(void) {
    uid_t
        newuid = getuid(),
        olduid = geteuid();
    gid_t
        newgid = getgid(),
        oldgid = getegid();

    if (setuid(newuid) == -1) {
        /* handle error condition */
        fatal_error();
    }
    if (setgid(newgid) == -1)  {
        /* handle error condition */
        fatal_error();
    }
    if (olduid == 0) {
        /* drop ancillary groups IDs only possible for root */
        if (setgroups(1, &newgid) == -1) {
            /* handle error condition */
            fatal_error();
        }
    }

    sanitize_privilege_drop_check(olduid, oldgid);
}
```

In this example, there are two privilege drops made in the incorrect order. `setgid` attempts to drop group privileges. However, `setgid` requires the user privileges, which were dropped previously using `setuid`, to perform this function. After dropping group

privileges, this function attempts to drop ancillary groups privileges by using `setgroups`. This task requires the higher primary group privileges that were dropped with `setgid`. At the end of this function, it is possible to regain group privileges because the order of dropping privileges was incorrect.

Correction — Reverse Privilege Drop Order

One possible correction is to drop the lowest level privileges first. In this correction, ancillary group privileges are dropped, then primary group privileges are dropped, and finally user privileges are dropped.

```
#define _BSD_SOURCE
#include <sys/types.h>
#include <unistd.h>
#include <grp.h>
#include <stdlib.h>
#define fatal_error() abort()

static void sanitize_privilege_drop_check(uid_t olduid, gid_t oldgid)
{
    if (seteuid(olduid) != -1)
    {
        /* Privileges can be restored, handle error */
        fatal_error();
    }
    if (setegid(oldgid) != -1)
    {
        /* Privileges can be restored, handle error */
        fatal_error();
    }
}
void badprivilegedroporder(void) {
    uid_t
        newuid = getuid(),
        olduid = geteuid();
    gid_t
        newgid = getgid(),
        oldgid = getegid();

    if (olduid == 0) {
        /* drop ancillary groups IDs only possible for root */
        if (setgroups(1, &newgid) == -1) {
            /* handle error condition */
            fatal_error();
```

```
        }
    }
    if (setgid(getgid()) == -1)  {
        /* handle error condition */
        fatal_error();
    }
    if (setuid(getuid()) == -1) {
        /* handle error condition */
        fatal_error();
    }

    sanitize_privilege_drop_check(olduid, oldgid);
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `BAD_PRIVILEGE_DROP_ORDER`
Impact: High
CWE ID: 250, 696

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2016b

Incorrect pointer scaling

Implicit scaling in pointer arithmetic might be ignored

Description

Incorrect pointer scaling occurs when Polyspace Bug Finder considers that you are ignoring the implicit scaling in pointer arithmetic.

For instance, the defect can occur in the following situations.

Situation	Risk	Possible Fix
You use the `sizeof` operator in arithmetic operations on a pointer.	The `sizeof` operator returns the size of a data type in number of bytes. Pointer arithmetic is already implicitly scaled by the size of the data type of the pointed variable. Therefore, the use of `sizeof` in pointer arithmetic produces unintended results.	Do not use `sizeof` operator in pointer arithmetic.
You perform arithmetic operations on a pointer, and then apply a cast.	Pointer arithmetic is implicitly scaled. If you do not consider this implicit scaling, casting the result of a pointer arithmetic produces unintended results.	Apply the cast before the pointer arithmetic.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click

options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Use of `sizeof` Operator

```
void func(void) {
    int arr[5] = {1,2,3,4,5};
    int *ptr = arr;

    int value_in_position_2 = *(ptr + 2*(sizeof(int)));
}
```

In this example, the operation `2*(sizeof(int))` returns twice the size of an `int` variable in bytes. However, because pointer arithmetic is implicitly scaled, the number of bytes by which `ptr` is offset is `2*(sizeof(int))*(sizeof(int))`.

In this example, the incorrect scaling shifts `ptr` outside the bounds of the array. Therefore, a **Pointer access out of bounds** error appears on the * operation.

Correction — Remove `sizeof` Operator

One possible correction is to remove the `sizeof` operator.

```
void func(void) {
    int arr[5] = {1,2,3,4,5};
    int *ptr = arr;

    int value_in_position_2 = *(ptr + 2);
}
```

Cast Following Pointer Arithmetic

```
int func(void) {
    int x = 0;
```

```
    char r = *(char *)(&x + 1);
    return r;
}
```

In this example, the operation `&x + 1` offsets `&x` by `sizeof(int)`. Following the operation, the resulting pointer points outside the allowed buffer. When you dereference the pointer, a **Pointer access out of bounds** error appears on the * operation.

Correction — Apply Cast Before Pointer Arithmetic

If you want to access the second byte of `x`, first cast `&x` to a `char*` pointer and then perform the pointer arithmetic. The resulting pointer is offset by `sizeof(char)` bytes and still points within the allowed buffer, whose size is `sizeof(int)` bytes.

```
int func(void) {
    int x = 0;
    char r = *((char *)(&x )+ 1);
    return r;
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `BAD_PTR_SCALING`
Impact: Medium
CWE ID: 468

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Umask used with chmod-style arguments

Argument to `umask` allows external user too much control

Description

Umask used with `chmod`-style arguments checks for `umask` commands that have an argument specified in the style of arguments to `chmod`.

For new files, the umask value specifies which permissions *not* to set, in other words which permissions to remove. The umask argument is bitwise-negated and then applied to new file permissions.

In contrast, chmod sets the permissions as you specify them.

Risk

If you use chmod-style arguments, you specify opposite permissions of what you want. This mistake can give external users unintended read/write access to new files and folders.

Fix

Set the umask so that the user (`u`) has fewer permissions turned off than the group (`g`). Set umask so that the group has fewer permissions turned off than other users (`o`), or `u <= g <= o`.

You can see the umask value by calling,

```
umask
```

or the symbolic value by calling,

```
umask -S
```

Examples

Setting the Default Mask

```
#include <stdio.h>
#include <assert.h>
#include <sys/types.h>
#include <sys/stat.h>

typedef mode_t (*umask_func)(mode_t);

const mode_t default_mode = (
    S_IRUSR    /* 00400 */
    | S_IWUSR  /* 00200 */
    | S_IRGRP  /* 00040 */
    | S_IWGRP  /* 00020 */
    | S_IROTH  /* 00004 */
    | S_IWOTH  /* 00002 */
    );         /* 00666 (i.e. -rw-rw-rw-) */

static void my_umask(mode_t mode)
{
    umask(mode);
}

int umask_use(mode_t m)
{
    my_umask(default_mode);
    return 0;
}
```

This example uses a function called `my_umask` to set the default mask mode. However, the `default_mode` variable gives the permissions 666 or `-rw-rw-rw`. `umask` negates this value. However, this negation means the default mask mode turns off read/write permissions for the user, group users, and other outside users.

Correction — Negate Preferred Permissions

One possible correction is to negate the `default_mode` argument to `my_umask`. This correction nullifies the negation `umask` for new files.

```
#include <stdio.h>
#include <assert.h>
```

```
#include <sys/types.h>
#include <sys/stat.h>

typedef mode_t (*umask_func)(mode_t);

const mode_t default_mode = (
    S_IRUSR    /* 00400 */
    | S_IWUSR  /* 00200 */
    | S_IRGRP  /* 00040 */
    | S_IWGRP  /* 00020 */
    | S_IROTH  /* 00004 */
    | S_IWOTH  /* 00002 */
    );         /* 00666 (i.e. -rw-rw-rw-) */

static void my_umask(mode_t mode)
{
    umask(mode);
}

int umask_use(mode_t m)
{
    my_umask(~default_mode);
    return 0;
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: BAD_UMASK
Impact: Low
CWE ID: 560, 922

See Also

Vulnerable permission assignments

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

External Websites

`umask` — Linux Manual Page

Introduced in R2015b

Missing lock

Unlock function without lock function

Description

Missing lock occurs when a task calls an unlock function before calling the corresponding lock function.

In multitasking code, a lock function begins a critical section of code and an unlock function ends it. When a task `my_task` calls a lock function `my_lock`, other tasks calling `my_lock` must wait till `my_task` calls the corresponding unlock function. Polyspace requires that both lock and unlock functions must have the form `void func(void)`.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**.

Risk

A call to an unlock function without a corresponding lock function can indicate a coding error. For instance, perhaps the unlock function does not correspond to the lock function that begins the critical section.

Fix

The fix depends on the root cause of the defect. For instance, if the defect occurs because of a mismatch between lock and unlock function, check the lock-unlock function pair in your Polyspace analysis configuration and fix the mismatch.

See examples of fixes below. To avoid the issue, you can follow the practice of calling the lock and unlock functions in the same module at the same level of abstraction. For instance, in this example, `func` calls the lock and unlock function at the same level but `func2` does not.

```
void func() {
  my_lock();
  {
    ...
```

```
  }
  my_unlock();
}

void func2() {
  {
   my_lock();
   ...
  }
  my_unlock();
}
```

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Missing lock

```
void begin_critical_section(void);
void end_critical_section(void);

int global_var;

void reset(void)
{
  begin_critical_section();
  global_var = 0;
  end_critical_section();
}

void my_task(void)
{
  global_var += 1;
  end_critical_section();
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	my_task, reset	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section	end_critical_section

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
   -entry-points my_task,reset
   -critical-section-begin begin_critical_section:cs1
   -critical-section-end end_critical_section:cs1
```

The example has two entry points, `my_task` and `reset`. `my_task` calls `end_critical_section` before calling `begin_critical_section`.

Correction — Provide Lock

One possible correction is to call the lock function `begin_critical_section` before the instructions in the critical section.

```
void begin_critical_section(void);
void end_critical_section(void);

int global_var;

void reset(void)
{
  begin_critical_section();
  global_var = 0;
  end_critical_section();
}
```

```
void my_task(void)
{
    begin_critical_section();
    global_var += 1;
    end_critical_section();
}
```

Lock in Condition

```
void begin_critical_section(void);
void end_critical_section(void);

int global_var;

void reset() {
    begin_critical_section();
    global_var=0;
    end_critical_section();
}

void my_task(void) {
    int index=0;
    volatile int numCycles;

    while(numCycles) {
      if(index%10==0) {
        begin_critical_section();
        global_var ++;
      }
      end_critical_section();
      index++;
    }
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	my_task, reset	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section	end_critical_section

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
   -entry-points my_task,reset
   -critical-section-begin begin_critical_section:cs1
   -critical-section-end end_critical_section:cs1
```

The example has two entry points, `my_task` and `reset`.

In the `while` loop, `my_task` leaves a critical section through the call `end_critical_section();`. In an iteration of the `while` loop:

- If `my_task` enters the `if` condition branch, the critical section begins through a call to `begin_critical_section`.
- If `my_task` does not enter the `if` condition branch and leaves the `while` loop, the critical section does not begin. Therefore, a **Missing lock** defect occurs.
- If `my_task` does not enter the `if` condition branch and continues to the next iteration of the `while` loop, the unlock function `end_critical_section` is called again. A **Double unlock** defect occurs.

Because `numCycles` is a `volatile` variable, it can take any value. Any of the cases above are possible. Therefore, a **Missing lock** defect and a **Double unlock** defect appear on the call `end_critical_section`.

Check Information

Group: Concurrency
Language: C | C++
Default: On
Command-Line Syntax: `BAD_UNLOCK`
Impact: Medium
CWE ID: 832

See Also

`Data race` | `Data race including atomic operations` | `Data race through standard library function call` | `Deadlock` | `Destruction of locked mutex` | `Double lock` | `Double unlock` | `Missing unlock`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2014b

Bitwise and arithmetic operation on the same data

Statement with mixed bitwise and arithmetic operations

Description

Bitwise and arithmetic operation on a same data detects statements with bitwise and arithmetic operations on the same variable or expression.

Risk

Mixed bitwise and arithmetic operations *do* compile. However, the size of integer types affects the result of these mixed operations. Mixed operations also reduce readability and maintainability.

Fix

Separate bitwise and arithmetic operations, or use only one type of operation per statement.

Examples

Shift and Addition

```
unsigned int bitwisearithmix()
{
    unsigned int var = 50;
    var += (var << 2) + 1;
    return var;
}
```

This example shows bitwise and arithmetic operations on the variable `var`. `var` is shifted by two (bitwise), then increased by 1 and added to itself (arithmetic).

Correction — Arithmetic Operations Only

You can reduce this expression to arithmetic-only operations: `var + (var << 2)` is equivalent to `var * 5`.

```
unsigned int bitwisearithmix()
{
    unsigned int var = 50;
    var = var * 5 +1;
    return var;
}
```

Result Information

Group: Good Practice
Language: C | C++
Default: Off
Command-Line Syntax: `BITWISE_ARITH_MIX`
Impact: Low
CWE ID: 710

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2016b

Bitwise operation on negative value

Undefined behavior for bitwise operations on negative values

Description

Bitwise operation on negative value detects bitwise operators (>>, ^, |, ~, but, not, &) used on signed integer variables with negative values.

Risk

If the value of the signed integer is negative, bitwise operation results can be unexpected because:

- Bitwise operations on negative values are compiler-specific.
- Unexpected calculations can lead to additional vulnerabilities, such as buffer overflow.

Fix

When performing bitwise operations, use `unsigned` integers to avoid unexpected results.

Examples

Right-Shift of Negative Integer

```
#include <stdio.h>
#include <stdarg.h>

static void demo_sprintf(const char *format, ...)
{
    int rc;
    va_list ap;
    char buf[sizeof("256")];

    va_start(ap, format);
    rc = vsprintf(buf, format, ap);
```

```
    if (rc == -1 || rc >= sizeof(buf)) {
        /* Handle error */
    }
    va_end(ap);
}

void bug_bitwiseneg()
{
    int stringify = 0x80000000;
    demo_sprintf("%u", stringify >> 24);
}
```

In this example, the statement `demo_sprintf("%u", stringify >> 24)` stops the program unexpectedly. You expect the result of `stringify >> 24` to be `0x80`. However, the actual result is `0xffffff80` because `stringify` is signed and negative. The sign bit is also shifted.

Correction — Add `unsigned` Keyword

By adding the `unsigned` keyword, `stringify` is not negative and the right-shift operation gives the expected result of `0x80`.

```
#include <stdio.h>
#include <stdarg.h>

static void demo_sprintf(const char *format, ...)
{
    int rc;
    va_list ap;
    char buf[sizeof("256")];

    va_start(ap, format);
    rc = vsprintf(buf, format, ap);
    if (rc == -1 || rc >= sizeof(buf)) {
        /* Handle error */
    }
    va_end(ap);
}

void corrected_bitwiseneg()
{
    unsigned int stringify = 0x80000000;
    demo_sprintf("%u", stringify >> 24);
}
```

Result Information

Group: Numerical
Language: C | C++
Default: Off
Command-Line Syntax: `BITWISE_NEG`
Impact: Medium
CWE ID: 682, 758

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2016b

Blocking operation while holding lock

Task performs lengthy operation while holding a lock

Description

Blocking operation while holding lock occurs when a task (thread) performs a potentially lengthy operation while holding a lock.

The checker considers calls to these functions as potentially lengthy:

- Functions that access a network such as `recv`
- System call functions such as `fork`, `pipe` and `system`
- Functions for I/O operations such as `getchar` and `scanf`
- File handling functions such as `fopen`, `remove` and `lstat`
- Directory manipulation functions such as `mkdir` and `rmdir`

The checker automatically detects certain primitives that hold and release a lock, for instance, `pthread_mutex_lock` and `pthread_mutex_unlock`. For the full list of primitives that are automatically detected, see the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

If a thread performs a lengthy operation when holding a lock, other threads that use the lock have to wait for the lock to be available. As a result, system performance can slow down or deadlocks can occur.

Fix

Perform the blocking operation before holding the lock or after releasing the lock.

Some functions detected by this checker can be called in a way that does not make them potentially lengthy. For instance, the function `recv` can be called with the parameter `O_NONBLOCK` which causes the call to fail if no message is available. When called with this parameter, `recv` does not wait for a message to become available.

Examples

Network I/O Operations with recv While Holding Lock

```
#include <pthread.h>
#include <sys/socket.h>

pthread_mutexattr_t attr;
pthread_mutex_t mutex;

void thread_foo(void *ptr) {
  unsigned int num;
  int result;
  int sock;

  /* sock is a connected TCP socket */

  if ((result = pthread_mutex_lock(&mutex)) != 0) {
    /* Handle Error */
  }

  if ((result = recv(sock, (void *)&num, sizeof(unsigned int), 0)) < 0) {
    /* Handle Error */
  }

  /* ... */

  if ((result = pthread_mutex_unlock(&mutex)) != 0) {
    /* Handle Error */
  }
}

int main() {
  pthread_t thread;
  int result;

  if ((result = pthread_mutexattr_settype(
      &attr, PTHREAD_MUTEX_ERRORCHECK)) != 0) {
    /* Handle Error */
  }

  if ((result = pthread_mutex_init(&mutex, &attr)) != 0) {
    /* Handle Error */
```

```
  }

  if (pthread_create(&thread, NULL,(void*(*)(void*))& thread_foo, NULL) != 0) {
    /* Handle Error */
  }

  /* ... */

  pthread_join(thread, NULL);

  if ((result = pthread_mutex_destroy(&mutex)) != 0) {
    /* Handle Error */
  }

  return 0;
}
```

In this example, in each thread created with `pthread_create`, the function `thread_foo` performs a network I/O operation with `recv` after acquiring a lock with `pthread_mutex_lock`. Other threads using the same lock variable `mutex` have to wait for the operation to complete and the lock to become available.

Correction — Perform Blocking Operation Before Acquiring Lock

One possible correction is to call `recv` before acquiring the lock.

```
#include <pthread.h>
#include <sys/socket.h>

pthread_mutexattr_t attr;
pthread_mutex_t mutex;

void thread_foo(void *ptr) {
  unsigned int num;
  int result;
  int sock;

  /* sock is a connected TCP socket */
  if ((result = recv(sock, (void *)&num, sizeof(unsigned int), 0)) < 0) {
    /* Handle Error */
  }

  if ((result = pthread_mutex_lock(&mutex)) != 0) {
    /* Handle Error */
```

```
  }

    /* ... */

  if ((result = pthread_mutex_unlock(&mutex)) != 0) {
    /* Handle Error */
  }
}

int main() {
  pthread_t thread;
  int result;

  if ((result = pthread_mutexattr_settype(
      &attr, PTHREAD_MUTEX_ERRORCHECK)) != 0) {
    /* Handle Error */
  }

  if ((result = pthread_mutex_init(&mutex, &attr)) != 0) {
    /* Handle Error */
  }

  if (pthread_create(&thread, NULL,(void*(*)(void*))& thread_foo, NULL) != 0) {
    /* Handle Error */
  }

  /* ... */

  pthread_join(thread, NULL);

  if ((result = pthread_mutex_destroy(&mutex)) != 0) {
    /* Handle Error */
  }

  return 0;
}
```

Result Information

Group: Concurrency
Language: C | C++
Default: Off
Command-Line Syntax: BLOCKING_WHILE_LOCKED

Impact: Low
CWE ID: 667

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

Return of non const handle to encapsulated data member

Method returns pointer or reference to internal member of object

Description

Return of non-const handle to encapsulated data member occurs when:

- A class method returns a handle to a data member. Handles include pointers and references.
- The method is more accessible than the data member. For instance, the method has access specifier `public`, but the data member is `private` or `protected`.

Risk

The access specifier determines the accessibility of a class member. For instance, a class member declared with the `private` access specifier cannot be accessed outside a class. Therefore, nonmember, nonfriend functions cannot modify the member.

When a class method returns a handle to a less accessible data member, the member accessibility changes. For instance, if a `public` method returns a pointer to a `private` data member, the data member is effectively not `private` anymore. A nonmember, nonfriend function calling the `public` method can use the returned pointer to view and modify the data member.

Also, if you assign the pointer to a data member of an object to another pointer, when you delete the object, the second pointer can be left dangling. The second pointer points to the part of an object that does not exist anymore.

Fix

One possible fix is to avoid returning a handle to a data member from a class method. Return a data member by value so that a copy of the member is returned. Modifying the copy does not change the data member.

If you must return a handle, use a `const` qualifier with the method return type so that the handle allows viewing, but not modifying, the data member.

Examples

Return of Pointer to `private` Data Member

```
#include <string>
#define NUM_RECORDS 100

struct Date {
    int dd;
    int mm;
    int yyyy;
};


struct Period {
    Date startDate;
    Date endDate;
};

class DataBaseEntry {
private:
    std::string employeeName;
    Period employmentPeriod;
public:
    Period* getPeriod(void);
};

Period* DataBaseEntry::getPeriod(void) {
    return &employmentPeriod;
}


void use(Period*);
void reset(Period*);

int main() {
    DataBaseEntry dataBase[NUM_RECORDS];
    Period* tempPeriod;
    for(int i=0;i < NUM_RECORDS;i++) {
```

```
        tempPeriod = dataBase[i].getPeriod();
        use(tempPeriod);
        reset(tempPeriod);
    }
    return 0;
}

void reset(Period* aPeriod) {
       aPeriod->startDate.dd = 1;
       aPeriod->startDate.mm = 1;
       aPeriod->startDate.yyyy = 2000;
}
```

In this example, `employmentPeriod` is `private` to the class `DataBaseEntry`. It is therefore immune from modification by nonmember, nonfriend functions. However, returning a pointer to `employmentPeriod` breaks this encapsulation. For instance, the nonmember function `reset` modifies the member `startDate` of `employmentPeriod`.

Correction: Return Member by Value

One possible correction is to return the data member `employmentPeriod` by value instead of pointer. Modifying the return value does not change the data member because the return value is a copy of the data member.

```
#include <string>
#define NUM_RECORDS 100

struct Date {
    int dd;
    int mm;
    int yyyy;
};


struct Period {
    Date startDate;
    Date endDate;
};

class DataBaseEntry {
private:
    std::string employeeName;
    Period employmentPeriod;
public:
```

```
    Period getPeriod(void);
};

Period DataBaseEntry::getPeriod(void) {
    return employmentPeriod;
}


void use(Period*);
void reset(Period*);

int main() {
    DataBaseEntry dataBase[NUM_RECORDS];
    Period tempPeriodVal;
    Period* tempPeriod;
    for(int i=0;i < NUM_RECORDS;i++) {
        tempPeriodVal = dataBase[i].getPeriod();
        tempPeriod = &tempPeriodVal;
        use(tempPeriod);
        reset(tempPeriod);
    }
    return 0;
}

void reset(Period* aPeriod) {
       aPeriod->startDate.dd = 1;
       aPeriod->startDate.mm = 1;
       aPeriod->startDate.yyyy = 2000;
}
```

Result Information

Group: Object oriented
Language: C++
Default: Off
Command-Line Syntax: BREAKING_DATA_ENCAPSULATION
Impact: Medium
CWE ID: 375, 767

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Character value absorbed into EOF

Data type conversion makes a valid character value same as End-of-File (EOF)

Description

Character value absorbed into EOF occurs when you perform a data type conversion that makes a valid character value indistinguishable from `EOF` (End-of-File). Bug Finder flags the defect in one of the following situations:

- *End-of-File*: You perform a data type conversion such as from `int` to `char` that converts a non-EOF character value into `EOF`.

  ```
  char ch = (char)getchar()
  ```

  You then compare the result with EOF.

  ```
  if((int)ch == EOF)
  ```

  The conversion can be explicit or implicit.
- *Wide End-of-File*: You perform a data type conversion that can convert a non-WEOF wide character value into WEOF, and then compare the result with WEOF.

Risk

The data type `char` cannot hold the value `EOF` that indicates the end of a file. Functions such as `getchar` have return type `int` to accommodate `EOF`. If you convert from `int` to `char`, the values `UCHAR_MAX` (a valid character value) and `EOF` get converted to the same value -1 and become indistinguishable from each other. When you compare the result of this conversion with `EOF`, the comparison can lead to false detection of `EOF`. This rationale also applies to wide character values and `WEOF`.

Fix

Perform the comparison with `EOF` or `WEOF` before conversion.

Examples

Return Value of `getchar` Converted to `char`

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

char func(void)
{
    char ch;
    ch = getchar();
    if (EOF == (int)ch) {
        fatal_error();
    }
    return ch;
}
```

In this example, the return value of `getchar` is implicitly converted to `char`. If `getchar` returns `UCHAR_MAX`, it is converted to -1, which is indistinguishable from EOF. When you compare with EOF later, it can lead to a false positive.

Correction — Perform Comparison with EOF Before Conversion

One possible correction is to first perform the comparison with EOF, and then convert from `int` to `char`.

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

char func(void)
{
    int i;
    i = getchar();
    if (EOF == i) {
        fatal_error();
    }
    else {
        return (char)i;
    }
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `CHAR_EOF_CONFUSED`
Impact: High
CWE ID: 704

See Also

`Errno not checked` | `Invalid use of standard library integer routine` | `Misuse of sign-extended character value` | `Returned value of a sensitive function not checked`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Misuse of sign-extended character value

Data type conversion with sign extension causes unexpected behavior

Description

Misuse of sign-extended character value occurs when you convert a signed or plain `char` variable containing possible negative values to a wider integer data type (or perform an arithmetic operation that does the conversion) and then use the resulting value in one of these ways:

- For comparison with `EOF` (using == or `!=`)
- As array index
- As argument to a character-handling function in `ctype.h`, for instance, `isalpha()` or `isdigit()`

If you convert a signed `char` variable with a negative value to a wider type such as `int`, the sign bit is preserved (sign extension). This can lead to specific problems even in situations where you think you have accounted for the sign bit.

For instance, the signed `char` value of -1 can represent the character `EOF` (end-of-file), which is an invalid character. Suppose a `char` variable `var` acquires this value. If you treat `var` as a `char` variable, you might want to write special code to account for this invalid character value. However, if you perform an operation such as `var++` (involving integer promotion), it leads to the value 0, which represents a valid value `'\0'` by accident. You transitioned from an invalid to a valid value through the arithmetic operation.

Even for negative values other than -1, a conversion from signed `char` to signed `int` can lead to other issues. For instance, the signed `char` value -126 is equivalent to the `unsigned char` value 130 (corresponding to an extended character `'\202'`). If you convert the value from `char` to `int`, the sign bit is preserved. If you then cast the resulting value to `unsigned int`, you get an unexpectedly large value, 4294967170 (assuming 32-bit `int`). If your code expects the `unsigned char` value of 130 in the final `unsigned int` variable, you can see unexpected results.

The underlying cause of this issue is the sign extension during conversion to a wider type. Most architectures use two's complement representation for storing values. In this

representation, the most significant bit indicates the sign of the value. When converted to a wider type, the conversion is done by copying this sign bit to all the leading bits of the wider type, so that the sign is preserved. For instance, the `char` value of -3 is represented as `11111101` (assuming 8-bit `char`). When converted to `int`, the representation is:

```
11111111 11111111 11111111  11111101
```

The value -3 is preserved in the wider type `int`. However, when converted to `unsigned int`, the value (4294967293) is no longer the same as the `unsigned char` equivalent of the original `char` value. If you are not aware of this issue, you can see unexpected results in your code.

Risk

In the following cases, Bug Finder flags use of variables after a conversion from `char` to a wider data type or an arithmetic operation that implicitly converts the variable to a wider data type:

- *If you compare the variable value with EOF*:

  A `char` value of -1 can represent the invalid character `EOF` or the valid extended character value `'\377'` (corresponding to the `unsigned char` equivalent, 255). After a `char` variable is cast to a wider type such as `int`, because of sign extension, the `char` value -1, representing one of `EOF` or `'\377'` becomes the `int` value -1, representing only `EOF`. The `unsigned char` value 255 can no longer be recovered from the `int` variable. Bug Finder flags this situation so that you can cast the variable to `unsigned char` first (or avoid the `char`-to-`int` conversion or converting operation before comparison with `EOF`). Only then, a comparison with `EOF` is meaningful. See “Sign-Extended Character Value Compared with EOF” on page 1-93.
- *If you use the variable value as an array index*:

  After a `char` variable is cast to a wider type such as `int`, because of sign extension, all negative values retain their sign. If you use the negative values directly to access an array, you cause buffer overflow/underflow. Even when you account for the negative values, the way you account for them might result in incorrect elements being read from the array. See “Sign-Extended Character Value Used as Array Index” on page 1-94.
- *If you pass the variable value as argument to a character-handling function*:

  According to the C11 standard (Section 7.4), if you supply an integer argument that cannot be represented as `unsigned char` or `EOF`, the resulting behavior is

undefined. Bug Finder flags this situation because negative `char` values after conversion can no longer be represented as `unsigned char` or `EOF`. For instance, the signed `char` value -126 is equivalent to the `unsigned char` value 130, but the signed `int` value -126 cannot be represented as `unsigned char` or `EOF`.

Fix

Before conversion to a wider integer data type, cast the signed or plain `char` value explicitly to `unsigned char`.

If you use the `char` data type to not represent characters but simply as a smaller data type to save memory, your use of sign-extended `char` values might avoid the risks mentioned earlier. If so, add comments to your result or code to avoid another review. See "Address Polyspace Results Through Bug Fixes or Comments".

Examples

Sign-Extended Character Value Compared with EOF

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

extern char parsed_token_buffer[20];

static int parser(char *buf)
{
    int c = EOF;
    if (buf && *buf) {
        c = *buf++;
    }
    return c;
}

void func()
{
    if (parser(parsed_token_buffer) == EOF) {
        /* Handle error */
        fatal_error();
    }
}
```

In this example, the function `parser` can traverse a string input `buf`. If a character in the string has the value -1, it can represent either `EOF` or the valid character value `'\377'` (corresponding to the `unsigned char` equivalent 255). When converted to the `int` variable `c`, its value becomes the integer value -1, which is always `EOF`. The later comparison with `EOF` will not detect if the value returned from `parser` is actually `EOF`.

Correction — Cast to `unsigned char` Before Conversion

One possible correction is to cast the plain `char` value to `unsigned char` before conversion to the wider `int` type. Only then can you test if the return value of `parser` is really `EOF`.

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

extern char parsed_token_buffer[20];

static int parser(char *buf)
{
    int c = EOF;
    if (buf && *buf) {
        c = (unsigned char)*buf++;
    }
    return c;
}

void func()
{
    if (parser(parsed_token_buffer) == EOF) {
        /* Handle error */
        fatal_error();
    }
}
```

Sign-Extended Character Value Used as Array Index

```
#include <limits.h>
#include <stddef.h>
#include <stdio.h>

#define NUL '\0'
#define SOH 1    /* start of heading */
```

```
#define STX 2    /* start of text */
#define ETX 3    /* end of text */
#define EOT 4    /* end of transmission */
#define ENQ 5    /* enquiry */
#define ACK 6    /* acknowledge */

static const int ascii_table[UCHAR_MAX + 1] =
{
      [0]=NUL,[1]=SOH, [2]=STX, [3]=ETX, [4]=EOT, [5]=ENQ,[6]=ACK,
      /* ... */
      [126] = '~',
      /* ... */
      [130/*-126*/]='\202',
      /* ... */
      [255 /*-1*/]='\377'
};

int lookup_ascii_table(char c)
{
    int i;
    i = (c < 0 ? -c : c);
    return ascii_table[i];
}
```

In this example, the `char` variable `c` is converted to the `int` variable `i`. If `c` has negative values, they are converted to positive values before assignment to `i`. However, this conversion can lead to unexpected values when `i` is used as array index. For instance:

- If `c` has the value -1 representing the invalid character `EOF`, you want to probably treat this value separately. However, in this example, a value of `c` equal to -1 leads to a value of `i` equal to 1. The function `lookup_ascii_table` returns the value `ascii_table[1]` (or `SOH`) without the invalid character value `EOF` being accounted for.

  If you use the `char` data type to not represent characters but simply as a smaller data type to save memory, you need not worry about this issue.
- If `c` has a negative value, when assigned to `i`, its sign is reversed. However, if you access the elements of `ascii_table` through `i`, this sign reversal can result in unexpected values being read.

For instance, if `c` has the value -126, `i` has the value 126. The function `lookup_ascii_table` returns the value `ascii_table[126]` (or `'~'`) but you probably expected the value `ascii_table[130]` (or `'\202'`).

Correction – Cast to `unsigned char`

To correct the issues, avoid the conversion from `char` to `int`. First, check `c` for the value `EOF`. Then, cast the value of the `char` variable `c` to `unsigned char` and use the result as array index.

```
#include <limits.h>
#include <stddef.h>
#include <stdio.h>

#define NUL '\0'
#define SOH 1    /* start of heading */
#define STX 2    /* start of text */
#define ETX 3    /* end of text */
#define EOT 4    /* end of transmission */
#define ENQ 5    /* enquiry */
#define ACK 6    /* acknowledge */

static const int ascii_table[UCHAR_MAX + 1] =
{
      [0]=NUL,[1]=SOH, [2]=STX, [3]=ETX, [4]=EOT, [5]=ENQ,[6]=ACK,
      /* ... */
      [126] = '~',
      /* ... */
      [130/*-126*/]='\202',
      /* ... */
      [255 /*-1*/]='\377'
};

int lookup_ascii_table(char c)
{
    int r = EOF;
    if (c != EOF) /* specific handling EOF, invalid character */
        r = ascii_table[(unsigned char)c]; /* cast to 'unsigned char' */
    return r;
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `CHARACTER_MISUSE`
Impact: Medium
CWE ID: 704

See Also

`Character value absorbed into EOF` | `Errno not checked` | `Invalid use of standard library integer routine` | `Returned value of a sensitive function not checked`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

File manipulation after `chroot()` without `chdir("/")`

Path-related vulnerabilities for file manipulated after call to `chroot`

Description

File manipulation after `chroot()` without `chdir("/")` detects access to the file system outside of the jail created by `chroot`. By calling `chroot`, you create a file system jail that confines access to a specific file subsystem. However, this jail is ineffective if you do not call `chdir("/")`.

Risk

If you do not call `chdir("/")` after creating a `chroot` jail, file manipulation functions that takes a path as an argument can access files outside of the jail. An attacker can still manipulate files outside the subsystem that you specified, making the chroot jail ineffective.

Fix

After calling `chroot`, call `chdir("/")` to make your `chroot` jail more secure.

Examples

Open File in `chroot`-jail

```
#include <unistd.h>
#include <stdio.h>

const char root_path[] = "/var/ftproot";
const char log_path[] = "file.log";
FILE* chrootmisuse() {
    FILE* res;
    chroot(root_path);
```

```
    chdir("base");
    res = fopen(log_path, "r");
    return res;
}
```

This example uses `chroot` to create a chroot-jail. However, to use the `chroot` jail securely, you must call `chdir("\")` afterward. This example calls `chdir("base")`, which is not equivalent. Bug Finder also flags `fopen` because `fopen` opens a file in the vulnerable `chroot`-jail.

Correction — Call `chdir("/")`

Before opening files, call `chdir("/")`.

```
#include <unistd.h>
#include <stdio.h>

const char root_path[] = "/var/ftproot";
const char log_path[] = "file.log";
FILE* chrootmisuse() {
    FILE* res;
    chroot(root_path);
    chdir("/");
    res = fopen(log_path, "r");
    return res;
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `CHROOT_MISUSE`
Impact: Medium
CWE ID: 243, 922

See Also

`Umask used with chmod-style arguments` | `Vulnerable path manipulation`

Topics

“Interpret Polyspace Bug Finder Access Results”

“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Use of previously closed resource

Function operates on a previously closed stream

Description

Use of previously closed resource occurs when a function operates on a stream that you closed earlier in your code.

Risk

The standard states that the value of a `FILE*` pointer is indeterminate after you close the stream associated with it. Operations using the `FILE*` pointer can produce unintended results.

Fix

One possible fix is to close the stream only at the end of operations. Another fix is to reopen the stream before using it again.

Examples

Use of `FILE*` Pointer After Closing Stream

```
#include <stdio.h>

void func(void) {
    FILE *fp;
    void *ptr;

    fp = fopen("tmp","w");
    if(fp != NULL) {
        fclose(fp);
        fprintf(fp,"text");
    }
}
```

In this example, `fclose` closes the stream associated with `fp`. When you use `fprintf` on `fp` after `fclose`, the **Use of previously closed resource** defect appears.

Correction — Close Stream After All Operations

One possible correction is to reverse the order of the `fprintf` and `fclose` operations.

```
#include <stdio.h>

void func(void) {
    FILE *fp;
    void *ptr;

    fp = fopen("tmp","w");
    if(fp != NULL) {
        fprintf(fp,"text");
        fclose(fp);
    }
}
```

Result Information

Group: Resource management
Language: C | C++
Default: On
Command-Line Syntax: `CLOSED_RESOURCE_USE`
Impact: High
CWE ID: 672, 826, 910

See Also

`MISRA C:2012 Rule 22.6`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Writing to const qualified object

Object declared with a `const` qualifier is modified

Description

Writing to `const` qualified object occurs when you do one of the following:

- Use a `const`-qualified object as the destination of an assignment.
- Pass a `const`-qualified object to a function that modifies the argument.

For instance, the defect can occur in the following situations:

- You pass a `const`-qualified object as first argument of one of the following functions:
  - `mkstemp`
  - `mkostemp`
  - `mkostemps`
  - `mkdtemp`
- You pass a `const`-qualified object as the destination argument of one of the following functions:
  - `strcpy`
  - `strncpy`
  - `strcat`
  - `memset`
- You perform a write operation on a `const`-qualified object.

Risk

The risk depends upon the modifications made to the `const`-qualified object.

Situation	Risk
Passing to `mkstemp`, `mkostemp`, `mkostemps`, `mkdtemp`, and so on.	These functions replace the last six characters of their first argument with a string. Therefore, they expect a modifiable `char` array as their first argument.
Passing to `strcpy`, `strncpy`, `strcat`, `memset` and so on.	These functions modify their destination argument. Therefore, they expect a modifiable `char` array as their destination argument.
Writing to the object	The `const` qualifier implies an agreement that the value of the object will not be modified. By writing to a `const`-qualified object, you break the agreement. The result of the operation is undefined.

Fix

The fix depends on the modification made to the `const`-qualified object.

Situation	Fix
Passing to `mkstemp`, `mkostemp`, `mkostemps`, `mkdtemp`, and so on.	Pass a non-`const` object as first argument of the function.
Passing to `strcpy`, `strncpy`, `strcat`, `memset` and so on.	Pass a non-`const` object as destination argument of the function.
Writing to the object	Perform the write operation on a non-`const` object.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Writing to `const`-Qualified Object

```
#include <string.h>

const char* buffer = "abcdeXXXXXXX";

void func(char* string) {
    char *ptr = (char*)strchr(buffer,'X');
    if(ptr)
        strcpy(ptr,string);
}
```

In this example, because `buffer` is `const`-qualified, `strchr(buffer,'X')` returns a `const`-qualified `char*` pointer. When this `char*` pointer is used as the destination argument of `strcpy`, a **Writing to const qualified object** error appears.

Correction — Copy `const`-Qualified Object to Non-`const` Object

One possible correction is to assign the constant string to a non-`const` object and use the non-`const` object as destination argument of `strchr`.

```
#include <string.h>

char buffer[] = "abcdeXXXXXXX";

void func(char* string) {
    char *ptr = (char*)strchr(buffer,'X');
    if(ptr)
        strcpy(ptr,string);
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `CONSTANT_OBJECT_WRITE`
Impact: High
CWE ID: 227, 471, 686

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Copy operation modifying source operand

Copy operation modifies data member of source object

Description

Copy operation modifying source operand occurs when a copy constructor or copy assignment operator modifies a mutable data member of its source operand.

For instance, this copy constructor `A` modifies the data member `m` of its source operand `other`:

```
class A {
  mutable int m;

public:
 ...
  A(const A &other) : m(other.m) {
    other.m = 0; //Modification of source
  }
}
```

Risk

A copy operation with a copy constructor (or copy assignment operator):

```
className new_object = old_object; //Calls copy constructor of className
```

copies its source operand `old_object` to its destination operand `new_object`. After the operation, you expect the destination operand to be a copy of the unmodified source operand. If the source operand is modified during copy, this assumption is violated.

Fix

Do not modify the source operand in the copy operation.

If you are modifying the source operand in a copy constructor to implement a move operation, use a move constructor instead. Move constructors are defined in the C++11 standard and later.

Examples

Copy Constructor Modifying Source

```
#include <algorithm>
#include <vector>

class A {
  mutable int m;

public:
  A() : m(0) {}
  explicit A(int m) : m(m) {}

  A(const A &other) : m(other.m) {
    other.m = 0;
  }

  A& operator=(const A &other) {
    if (&other != this) {
      m = other.m;
      other.m = 0;
    }
    return *this;
  }

  int get_m() const { return m; }
};

void f() {
  std::vector<A> v{10};
  A obj(12);
  std::fill(v.begin(), v.end(), obj);
}
```

In this example, a vector of ten objects of type `A` is created. The `std::fill` function copies an object of type `A`, which has a data member with value 12, to each of the ten objects. After this operation, you might expect that all ten objects in the vector have a data member with value 12.

However, the first copy modifies the data member of the source to the value 0. The remaining nine copies copy this value. After the `std::fill` call, the first object in the

vector has a data member with value 12 and the remaining objects have data members with value 0.

Correction — Use Move Constructor for Modifying Source

Do not modify data members of the source operand in a copy constructor or copy assignment operator. If you want your class to have a move operation, use a move constructor instead of a copy constructor.

In this corrected example, the copy constructor and copy assignment operator of class `A` do not modify the data member `m`. A separate move constructor modifies the source operand.

```
#include <algorithm>
#include <vector>

class A {
  int m;

public:
  A() : m(0) {}
  explicit A(int m) : m(m) {}

  A(const A &other) : m(other.m) {}
  A(A &&other) : m(other.m) { other.m = 0; }

  A& operator=(const A &other) {
    if (&other != this) {
      m = other.m;
    }
    return *this;
  }

  //Move constructor
  A& operator=(A &&other) {
    m = other.m;
    other.m = 0;
    return *this;
  }

  int get_m() const { return m; }
};
```

```
void f() {
  std::vector<A> v{10};
  A obj(12);
  std::fill(v.begin(), v.end(), obj);
}
```

Result Information

Group: Object Oriented
Language: C++
Default: On
Command-Line Syntax: `COPY_MODIFYING_SOURCE`
Impact: Medium

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

External Websites

Move constructors (C++11 and beyond)

Introduced in R2018b

Inconsistent cipher operations

You perform encryption and decryption steps in succession with the same cipher context without a reinitialization in between

Description

Inconsistent cipher operations occurs when you perform an encryption and decryption step with the same cipher context. You do not reinitialize the context in between those steps. The checker applies to symmetric encryption only.

For instance, you set up a cipher context for decryption using `EVP_DecryptInit_ex`.

```
EVP_DecryptInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv);
```

However, you use the context for encryption using `EVP_EncryptUpdate`.

```
EVP_EncryptUpdate(ctx, out_buf, &out_len, src, len);
```

Risk

Mixing up encryption and decryption steps can lead to obscure code. It is difficult to determine at a glance whether the current cipher context is used for encryption or decryption. The mixup can also lead to race conditions, failed encryption, and unexpected ciphertext.

Fix

After you set up a cipher context for a certain family of operations, use the context for only that family of operations.

For instance, if you set up a cipher context for decryption using `EVP_DecryptInit_ex`, use the context afterward for decryption only.

Examples

Encryption Step Following Decryption Step

```
#include <openssl/evp.h>
#include <stdlib.h>

/* Using the cryptographic routines */

unsigned char *out_buf;
int out_len;
unsigned char g_key[16];
unsigned char g_iv[16];
void func(unsigned char* src, int len) {

    EVP_CIPHER_CTX *ctx = EVP_CIPHER_CTX_new();
    EVP_CIPHER_CTX_init(ctx);

    /* Cipher context set up for decryption*/
    EVP_DecryptInit_ex(ctx, EVP_aes_128_cbc(), NULL, g_key, g_iv);

    /* Update step for encryption */
    EVP_EncryptUpdate(ctx, out_buf, &out_len, src, len);
}
```

In this example, the cipher context `ctx` is set up for decryption using `EVP_DecryptInit_ex`. However, immediately afterward, the context is used for encryption using `EVP_EncryptUpdate`.

Correction — Change Setup Step

One possible correction is to change the setup step. If you want to use the cipher context for encryption, set it up using `EVP_EncryptInit_ex`.

```
#include <openssl/evp.h>
#include <stdlib.h>

unsigned char *out_buf;
```

```
int out_len;
unsigned char g_key[16];
unsigned char g_iv[16];

void func(unsigned char* src, int len) {
    EVP_CIPHER_CTX *ctx = EVP_CIPHER_CTX_new();
    EVP_CIPHER_CTX_init(ctx);

    /* Cipher context set up for encryption*/
    EVP_EncryptInit_ex(ctx, EVP_aes_128_cbc(), NULL, g_key, g_iv);

    /* Update step for encryption */
    EVP_EncryptUpdate(ctx, out_buf, &out_len, src, len);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_CIPHER_BAD_FUNCTION`
Impact: Medium
CWE ID: 372, 664

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Constant block cipher initialization vector

Initialization vector is constant instead of randomized

Description

Constant block cipher initialization vector occurs when you use a constant for the initialization vector (IV) during encryption.

Risk

Using a constant IV is equivalent to not using an IV. Your encrypted data is vulnerable to dictionary attacks.

Block ciphers break your data into blocks of fixed size. Block cipher modes such as CBC (Cipher Block Chaining) protect against dictionary attacks by XOR-ing each block with the encrypted output from the previous block. To protect the first block, these modes use a random initialization vector (IV). If you use a constant IV to encrypt multiple data streams that have a common beginning, your data becomes vulnerable to dictionary attacks.

Fix

Produce a random IV by using a strong random number generator.

For a list of random number generators that are cryptographically weak, see `Vulnerable pseudo-random number generator`.

Examples

Constants Used for Initialization Vector

```
#include <openssl/evp.h>
#include <stdlib.h>
```

```
#define SIZE16 16

/* Using the cryptographic routines */

int func(EVP_CIPHER_CTX *ctx, unsigned char *key){
    unsigned char iv[SIZE16] = {'1', '2', '3', '4','5','6','b','8','9',
                                '1','2','3','4','5','6','7'};
    return EVP_CipherInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv, 1);
}
```

In this example, the initialization vector `iv` has constants only. The constant initialization vector makes your cipher vulnerable to dictionary attacks.

Correction — Use Random Initialization Vector

One possible correction is to use a strong random number generator to produce the initialization vector. The corrected code here uses the function `RAND_bytes` declared in `openssl/rand.h`.

```
#include <openssl/evp.h>
#include <openssl/rand.h>
#include <stdlib.h>
#define SIZE16 16

/* Using the cryptographic routines */

int func(EVP_CIPHER_CTX *ctx, unsigned char *key){
    unsigned char iv[SIZE16];
    RAND_bytes(iv, 16);
    return EVP_CipherInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv, 1);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_CIPHER_CONSTANT_IV`
Impact: Medium
CWE ID: 310, 326, 329

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Constant cipher key

Encryption or decryption key is constant instead of randomized

Description

Constant cipher key occurs when you use a constant for the encryption or decryption key.

Risk

If you use a constant for the encryption or decryption key, an attacker can retrieve your key easily.

You use a key to encrypt and later decrypt your data. If a key is easily retrieved, data encrypted using that key is not secure.

Fix

Produce a random key by using a strong random number generator.

For a list of random number generators that are cryptographically weak, see `Vulnerable pseudo-random number generator`.

Examples

Constants Used for Key

```
#include <openssl/evp.h>
#include <stdlib.h>
#define SIZE16 16

int func(EVP_CIPHER_CTX *ctx, unsigned char *iv){
    unsigned char key[SIZE16] = {'1', '2', '3', '4','5','6','b','8','9',
```

```
                                    '1','2','3','4','5','6','7'};
    return EVP_CipherInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv, 1);
}
```

In this example, the cipher key, `key`, has constants only. An attacker can easily retrieve a constant key.

Correction — Use Random Key

Use a strong random number generator to produce the cipher key. The corrected code here uses the function `RAND_bytes` declared in `openssl/rand.h`.

```
#include <openssl/evp.h>
#include <openssl/rand.h>
#include <stdlib.h>
#define SIZE16 16

int func(EVP_CIPHER_CTX *ctx, unsigned char *iv){
    unsigned char key[SIZE16];
    RAND_bytes(key, 16);
    return EVP_CipherInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv, 1);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_CIPHER_CONSTANT_KEY`
Impact: Medium
CWE ID: 310, 320, 321, 326, 522

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Missing cipher algorithm

An encryption or decryption algorithm is not associated with the cipher context

Description

Missing cipher algorithm occurs when you do not assign a cipher algorithm when setting up your cipher context.

You can initialize your cipher context without an algorithm. However, before you encrypt or decrypt your data, you must associate the cipher context with a cipher algorithm.

Risk

A missing cipher algorithm can lead to run-time errors or at least, non-secure ciphertext.

Before encryption or decryption, you set up a cipher context that has the information required for encryption: the cipher algorithm and mode, an encryption or decryption key and an initialization vector (for modes that require initialization vectors).

```
ret = EVP_EncryptInit(&ctx, EVP_aes_128_cbc(), key, iv)
```

The function `EVP_aes_128_cbc()` specifies that the Advanced Encryption Standard (AES) algorithm must be used for encryption. The function also specifies a block size of 128 bits and the Cipher Bloch Chaining (CBC) mode.

Instead of specifying the algorithm, you can use NULL in the initialization step. However, before using the cipher context for encryption or decryption, you must perform an additional initialization that associates an algorithm with the context. Otherwise, the update steps for encryption or decryption can lead to run-time errors.

Fix

Before your encryption or decryption steps

```
ret = EVP_EncryptUpdate(&ctx, out_buf, &out_len, src, len)
```

associate your cipher context `ctx` with an algorithm.

```
ret = EVP_EncryptInit(ctx, EVP_aes_128_cbc(), key, iv)
```

Examples

Algorithm Missing During Context Initialization

```
#include <openssl/evp.h>
#include <stdlib.h>
#define SIZE16 16

unsigned char key[SIZE16];
unsigned char iv[SIZE16];
void func(void) {
    EVP_CIPHER_CTX *ctx = EVP_CIPHER_CTX_new();
    EVP_CIPHER_CTX_init(ctx);
    EVP_EncryptInit_ex(ctx, NULL, NULL, key, iv);
}
```

In this example, an algorithm is not provided when the cipher context `ctx` is initialized.

Before you encrypt or decrypt your data, you have to provide a cipher algorithm. If you perform a second initialization to provide the algorithm, the cipher context is completely re-initialized. Therefore, the current initialization statement using `EVP_EncryptInit_ex` is redundant.

Correction — Provide Algorithm During Initialization

One possible correction is to provide an algorithm when you initialize the cipher context. In the corrected code below, the routine `EVP_aes_128_cbc` invokes the Advanced Encryption Standard (AES) algorithm. The routine also specifies a block size of 128 bits and the Cipher Block Chaining (CBC) mode for encryption.

```
#include <openssl/evp.h>
#include <stdlib.h>
#define SIZE16 16

unsigned char key[SIZE16];
```

```
unsigned char iv[SIZE16];
void func(unsigned char *src, int len, unsigned char *out_buf, int out_len) {
    EVP_CIPHER_CTX *ctx = EVP_CIPHER_CTX_new();
    EVP_CIPHER_CTX_init(ctx);

    /* Initialization of cipher context */
    EVP_EncryptInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv);

    /* Update steps for encryption */
    EVP_EncryptUpdate(ctx, out_buf, &out_len, src, len);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_CIPHER_NO_ALGORITHM`
Impact: Medium
CWE ID: 310, 573

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Missing cipher data to process

Final encryption or decryption step is performed without previous update steps

Description

Missing cipher data to process occurs when you perform the final step of a block cipher encryption or decryption incorrectly.

For instance, you do one of the following:

- You do not perform update steps for encrypting or decrypting the data before performing a final step.

  ```
  /* Initialization of cipher context */
  ret = EVP_EncryptInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv);
  ...
  /* Missing update step */
  ...
  /* Final step */
  ret = EVP_EncryptFinal_ex(ctx, out_buf, &out_len);
  ```

- You perform consecutive final steps without intermediate initialization and update steps.

  ```
  /* Initialization of cipher context */
  ret = EVP_EncryptInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv);
  ...
  /* Update step(s) */
  ret = EVP_EncryptUpdate(ctx, out_buf, &out_len, src, len);
  ...
  /* Final step */
  ret = EVP_EncryptFinal_ex(ctx, out_buf, &out_len);
  ...
  /* Missing initialization and update */
  ...
  /* Second final step */
  ret = EVP_EncryptFinal_ex(ctx, out_buf, &out_len);
  ```

- You perform a cleanup of the cipher context and then perform a final step.

  ```
  /* Initialization of cipher context */
  ret = EVP_EncryptInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv);
  ```

```
...
/* Update step(s) */
ret = EVP_EncryptUpdate(ctx, out_buf, &out_len, src, len);
...
/* Cleanup of cipher context */
EVP_CIPHER_CTX_cleanup(ctx);
...
/* Second final step */
ret = EVP_EncryptFinal_ex(ctx, out_buf, &out_len);
```

Risk

Block ciphers break your data into blocks of fixed size. During encryption or decryption, the update step encrypts or decrypts your data in blocks. Any leftover data is encrypted or decrypted by the final step. The final step adds padding to the leftover data so that it occupies one block, and then encrypts or decrypts the padded data.

If you perform the final step before performing the update steps, or perform the final step when there is no data to process, the behavior is undefined. You can also encounter run-time errors.

Fix

Perform encryption or decryption in this sequence:

- Initialization of cipher context
- Update steps
- Final step
- Cleanup of context

Examples

Missing Update Steps for Encryption Before Final Step

```
#include <openssl/evp.h>
#include <stdlib.h>
```

```
#define SIZE16 16

unsigned char *out_buf;
int out_len;
unsigned char key[SIZE16];
unsigned char iv[SIZE16];

void func(void) {
    EVP_CIPHER_CTX *ctx = EVP_CIPHER_CTX_new();
    EVP_CIPHER_CTX_init(ctx);

    /* Initialization of cipher context */
    EVP_EncryptInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv);

    /* Missing update steps for encryption */

    /* Final encryption step */
    EVP_EncryptFinal_ex(ctx, out_buf, &out_len);
}
```

In this example, after the cipher context is initialized, there are no update steps for encrypting the data. The update steps are supposed to encrypt one or more blocks of data, leaving the final step to encrypt data that is left over in a partial block. If you perform the final step without previous update steps, the behavior is undefined.

Correction — Perform Update Steps for Encryption Before Final Step

Perform update steps for encryption before the final step. In the corrected code below, the routine `EVP_EncryptUpdate` performs the update steps.

```
#include <openssl/evp.h>
#include <stdlib.h>
#define SIZE16 16

unsigned char *out_buf;
int out_len;
unsigned char key[SIZE16];
unsigned char iv[SIZE16];

void func(unsigned char *src, int len) {
    EVP_CIPHER_CTX *ctx = EVP_CIPHER_CTX_new();
    EVP_CIPHER_CTX_init(ctx);
```

```
    /* Initialization of cipher context */
    EVP_EncryptInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv);

    /* Update steps for encryption */
    EVP_EncryptUpdate(ctx, out_buf, &out_len, src, len);

    /* Final encryption step */
    EVP_EncryptFinal_ex(ctx, out_buf, &out_len);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_CIPHER_NO_DATA`
Impact: Medium
CWE ID: 311, 325, 372, 664

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Missing cipher final step

You do not perform a final step after update steps for encrypting or decrypting data

Description

Missing cipher final step occurs when you do not perform a final step after your update steps for encrypting or decrypting data.

For instance, you do the following:

```
/* Initialization of cipher context */
ret = EVP_EncryptInit_ex(&ctx, EVP_aes_128_cbc(), NULL, key, iv);
...
/* Update step */
ret = EVP_EncryptUpdate(&ctx, out_buf, &out_len, src, len);
...
/* Missing final step */
...
/* Cleanup of cipher context */
EVP_CIPHER_CTX_cleanup(ctx);
```

Risk

Block ciphers break your data into blocks of fixed size. During encryption or decryption, the update step encrypts or decrypts your data in blocks. Any leftover data is encrypted or decrypted by the final step. The final step adds padding to the leftover data so that it occupies one block, and then encrypts or decrypts the padded data.

If you do not perform the final step, leftover data remaining in a partial block is not encrypted or decrypted. You can face incomplete or unexpected output.

Fix

After your update steps for encryption or decryption, perform a final step to encrypt or decrypt leftover data.

```
/* Initialization of cipher context */
ret = EVP_EncryptInit_ex(&ctx, EVP_aes_128_cbc(), NULL, key, iv);
```

```
...
/* Update step(s) */
ret = EVP_EncryptUpdate(&ctx, out_buf, &out_len, src, len);
...
/* Final step */
ret = EVP_EncryptFinal_ex(&ctx, out_buf, &out_len);
...
/* Cleanup of cipher context */
EVP_CIPHER_CTX_cleanup(ctx);
```

Examples

Cleanup of Cipher Context Before Final Step

```
#include <openssl/evp.h>
#include <stdlib.h>
#define SIZE16 16

unsigned char *out_buf;
int out_len;
unsigned char key[SIZE16];
unsigned char iv[SIZE16];

void func(unsigned char *src, int len) {
    EVP_CIPHER_CTX *ctx = EVP_CIPHER_CTX_new();
    EVP_CIPHER_CTX_init(ctx);

    /* Initialization of cipher context */
    EVP_EncryptInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv);

    /* Update steps for encryption */
    EVP_EncryptUpdate(ctx, out_buf, &out_len, src, len);

    /* Missing final encryption step */

    /* Cleanup of cipher context */
    EVP_CIPHER_CTX_cleanup(ctx);
}
```

In this example, the cipher context `ctx` is cleaned up before a final encryption step. The final step is supposed to encrypt leftover data. Without the final step, the encryption is incomplete.

Correction — Perform Final Encryption Step

After your update steps for encryption, perform a final encryption step to encrypt leftover data. In the corrected code below, the routine `EVP_EncryptFinal_ex` is used to perform this final step.

```
#include <openssl/evp.h>
#include <stdlib.h>
#define SIZE16 16

unsigned char *out_buf;
int out_len;
unsigned char key[SIZE16];
unsigned char iv[SIZE16];

void func(unsigned char *src, int len) {
    EVP_CIPHER_CTX *ctx = EVP_CIPHER_CTX_new();
    EVP_CIPHER_CTX_init(ctx);

    /* Initialization of cipher context */
    EVP_EncryptInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv);

    /* Update steps for encryption */
    EVP_EncryptUpdate(ctx, out_buf, &out_len, src, len);

    /* Final encryption step */
    EVP_EncryptFinal_ex(ctx, out_buf, &out_len);

    /* Cleanup of cipher context */
    EVP_CIPHER_CTX_cleanup(ctx);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off

Command-Line Syntax: `CRYPTO_CIPHER_NO_FINAL`
Impact: Medium
CWE ID: 311, 325, 372, 664

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Missing block cipher initialization vector

Context used for encryption or decryption is associated with NULL initialization vector or not associated with an initialization vector

Description

Missing block cipher initialization vector occurs when you encrypt or decrypt data using a NULL initialization vector (IV).

Note You can initialize your cipher context with a NULL initialization vector (IV). However, if your algorithm requires an IV, before the encryption or decryption step, you must associate the cipher context with a non-NULL IV.

Risk

Many block cipher modes use an initialization vector (IV) to prevent dictionary attacks. If you use a NULL IV, your encrypted data is vulnerable to such attacks.

Block ciphers break your data into blocks of fixed size. Block cipher modes such as CBC (Cipher Block Chaining) protect against dictionary attacks by XOR-ing each block with the encrypted output from the previous block. To protect the first block, these modes use a random initialization vector (IV). If you use a NULL IV, you get the same ciphertext when encrypting the same plaintext. Your data becomes vulnerable to dictionary attacks.

Fix

Before your encryption or decryption steps

```
 ret = EVP_EncryptUpdate(&ctx, out_buf, &out_len, src, len)
```

associate your cipher context `ctx` with a non-NULL initialization vector.

```
ret = EVP_EncryptInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv)
```

Examples

NULL Initialization Vector Used for Encryption

```
#include <openssl/evp.h>
#include <stdlib.h>
#define fatal_error() abort()

unsigned char *out_buf;
int out_len;

int func(EVP_CIPHER_CTX *ctx, unsigned char *key, unsigned char *src, int len){
    if (key == NULL)
        fatal_error();

    /* Last argument is initialization vector */
    EVP_EncryptInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, NULL);

    /* Update step with NULL initialization vector */
    return EVP_EncryptUpdate(ctx, out_buf, &out_len, src, len);
}
```

In this example, the initialization vector associated with the cipher context `ctx` is NULL. If you use this context to encrypt your data, your data is vulnerable to dictionary attacks.

Correction — Use Random Initialization Vector

Use a strong random number generator to produce the initialization vector. The corrected code here uses the function `RAND_bytes` declared in `openssl/rand.h`.

```
#include <openssl/evp.h>
#include <openssl/rand.h>
#include <stdlib.h>
#define fatal_error() abort()
#define SIZE16 16

unsigned char *out_buf;
int out_len;
```

```
int func(EVP_CIPHER_CTX *ctx, unsigned char *key, unsigned char *src, int len){
    if (key == NULL)
        fatal_error();
    unsigned char iv[SIZE16];
    RAND_bytes(iv, 16);

    /* Last argument is initialization vector */
    EVP_EncryptInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv);

    /* Update step with non-NULL initialization vector */
    return EVP_EncryptUpdate(ctx, out_buf, &out_len, src, len);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_CIPHER_NO_IV`
Impact: Medium
CWE ID: 310, 326, 329

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Missing cipher key

Context used for encryption or decryption is associated with NULL key or not associated with a key

Description

Missing cipher key occurs when you encrypt or decrypt data using a NULL encryption or decryption key.

Note You can initialize your cipher context with a NULL key. However, before you encrypt or decrypt your data, you must associate the cipher context with a non-NULL key.

Risk

Encryption or decryption with a NULL key can lead to run-time errors or at least, non-secure ciphertext.

Fix

Before your encryption or decryption steps

```
ret = EVP_EncryptUpdate(&ctx, out_buf, &out_len, src, len)
```

associate your cipher context `ctx` with a non-NULL key.

```
ret = EVP_EncryptInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv)
```

Sometimes, you initialize your cipher context with a non-NULL key

```
ret = EVP_EncryptInit_ex(&ctx, cipher_algo_1, NULL, key, iv)
```

but change the cipher algorithm later. When you change the cipher algorithm, you use a NULL key.

```
ret = EVP_EncryptInit_ex(&ctx, cipher_algo_2, NULL, NULL, NULL)
```

The second statement reinitializes the cipher context completely but with a NULL key. To avoid this issue, every time you initialize a cipher context with an algorithm, associate it with a key.

Examples

NULL Key Used for Encryption

```
#include <openssl/evp.h>
#include <stdlib.h>
#define fatal_error() abort()

unsigned char *out_buf;
int out_len;

int func(EVP_CIPHER_CTX *ctx, unsigned char *iv, unsigned char *src, int len){
    if (iv == NULL)
        fatal_error();

    /* Fourth argument is cipher key */
    EVP_EncryptInit_ex(ctx, EVP_aes_128_cbc(), NULL, NULL, iv);

    /* Update step with NULL key */
    return EVP_EncryptUpdate(ctx, out_buf, &out_len, src, len);
}
```

In this example, the cipher key associated with the context `ctx` is NULL. When you use this context to encrypt your data, you can encounter run-time errors.

Correction — Use Random Cipher Key

Use a strong random number generator to produce the cipher key. The corrected code here uses the function `RAND_bytes` declared in `openssl/rand.h`.

```
#include <openssl/evp.h>
#include <openssl/rand.h>
#include <stdlib.h>
#define fatal_error() abort()
```

```
#define SIZE16 16

unsigned char *out_buf;
int out_len;

int func(EVP_CIPHER_CTX *ctx, unsigned char *iv, unsigned char *src, int len){
    if (iv == NULL)
        fatal_error();
    unsigned char key[SIZE16];
    RAND_bytes(key, 16);

    /* Fourth argument is cipher key */
    EVP_EncryptInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv);

    /* Update step with non-NULL cipher key */
    return EVP_EncryptUpdate(ctx, out_buf, &out_len, src, len);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_CIPHER_NO_KEY`
Impact: Medium
CWE ID: 310, 320, 573, 664

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Predictable block cipher initialization vector

Initialization vector is generated from a weak random number generator

Description

Predictable block cipher initialization vector occurs when you use a weak random number generator for the block cipher initialization vector.

Risk

If you use a weak random number generator for the initiation vector, your data is vulnerable to dictionary attacks.

Block ciphers break your data into blocks of fixed size. Block cipher modes such as CBC (Cipher Block Chaining) protect against dictionary attacks by XOR-ing each block with the encrypted output from the previous block. To protect the first block, these modes use a random initialization vector (IV). If you use a weak random number generator for your IV, your data becomes vulnerable to dictionary attacks.

Fix

Use a strong pseudo-random number generator (PRNG) for the initialization vector. For instance, use:

- OS-level PRNG such as `/dev/random` on UNIX® or `CryptGenRandom()` on Windows
- Application-level PRNG such as Advanced Encryption Standard (AES) in Counter (CTR) mode, HMAC-SHA1, etc.

For a list of random number generators that are cryptographically weak, see `Vulnerable pseudo-random number generator`.

Examples

Predictable Initialization Vector

```
#include <openssl/evp.h>
#include <openssl/rand.h>
#include <stdlib.h>
#define SIZE16 16

int func(EVP_CIPHER_CTX *ctx, unsigned char *key){
    unsigned char iv[SIZE16];
    RAND_pseudo_bytes(iv, 16);
    return EVP_CipherInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv, 1);
}
```

In this example, the function `RAND_pseudo_bytes` declared in `openssl/rand.h` produces the initialization vector. The byte sequences that `RAND_pseudo_bytes` generates are not necessarily unpredictable.

Correction — Use Strong Random Number Generator

Use a strong random number generator to produce the initialization vector. The corrected code here uses the function `RAND_bytes` declared in `openssl/rand.h`.

```
#include <openssl/evp.h>
#include <openssl/rand.h>
#include <stdlib.h>
#define SIZE16 16

int func(EVP_CIPHER_CTX *ctx, unsigned char *key){
    unsigned char iv[SIZE16];
    RAND_bytes(iv, 16);
    return EVP_CipherInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv, 1);
}
```

Result Information

Group: Cryptography
Language: C | C++

Default: Off
Command-Line Syntax: `CRYPTO_CIPHER_PREDICTABLE_IV`
Impact: Medium
CWE ID: 310, 329, 330, 338

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Predictable cipher key

Encryption or decryption key is generated from a weak random number generator

Description

Predictable cipher key occurs when you use a weak random number generator for the encryption or decryption key.

Risk

If you use a weak random number generator for the encryption or decryption key, an attacker can retrieve your key easily.

You use a key to encrypt and later decrypt your data. If a key is easily retrieved, data encrypted using that key is not secure.

Fix

Use a strong pseudo-random number generator (PRNG) for the key. For instance:

- Use an OS-level PRNG such as `/dev/random` on UNIX or `CryptGenRandom()` on Windows
- Use an application-level PRNG such as Advanced Encryption Standard (AES) in Counter (CTR) mode, HMAC-SHA1, etc.

For a list of random number generators that are cryptographically weak, see `Vulnerable pseudo-random number generator`.

Examples

Predictable Cipher Key

```
#include <openssl/evp.h>
#include <openssl/rand.h>
#include <stdlib.h>
#define SIZE16 16

int func(EVP_CIPHER_CTX *ctx, unsigned char *iv){
    unsigned char key[SIZE16];
    RAND_pseudo_bytes(key, 16);
    return EVP_CipherInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv, 1);
}
```

In this example, the function `RAND_pseudo_bytes` declared in `openssl/rand.h` produces the cipher key. However, the byte sequences that `RAND_pseudo_bytes` generates are not necessarily unpredictable.

Correction — Use Strong Random Number Generator

One possible correction is to use a strong random number generator to produce the cipher key. The corrected code here uses the function `RAND_bytes` declared in `openssl/rand.h`.

```
#include <openssl/evp.h>
#include <openssl/rand.h>
#include <stdlib.h>
#define SIZE16 16

int func(EVP_CIPHER_CTX *ctx, unsigned char *iv){
    unsigned char key[SIZE16];
    RAND_bytes(key, 16);
    return EVP_CipherInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv, 1);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_CIPHER_PREDICTABLE_KEY`
Impact: Medium
CWE ID: 310, 326, 330, 338

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Weak cipher algorithm

Encryption algorithm associated with the cipher context is weak

Description

Weak cipher algorithm occurs when you associate a weak encryption algorithm with the cipher context.

Risk

Some encryption algorithms have known flaws. Though the OpenSSL library still supports the algorithms, you must avoid using them.

If your cipher algorithm is weak, an attacker can decrypt your data by exploiting a known flaw or brute force attacks.

Fix

Use algorithms that are well-studied and widely acknowledged as secure.

For instance, the Advanced Encryption Standard (AES) is a widely accepted cipher algorithm.

Examples

Use of DES Algorithm

```
#include <openssl/evp.h>
#include <stdlib.h>

void func(unsigned char *key, unsigned char *iv) {
    EVP_CIPHER_CTX *ctx = EVP_CIPHER_CTX_new();
    EVP_CIPHER_CTX_init(ctx);
```

```
    const EVP_CIPHER * ciph = EVP_des_cbc();
    EVP_EncryptInit_ex(ctx, ciph, NULL, key, iv);
}
```

In this example, the routine `EVP_des_cbc()` invokes the Data Encryption Standard (DES) algorithm, which is now considered as non-secure and relatively slow.

Correction — Use AES Algorithm

One possible correction is to use the faster and more secure Advanced Encryption Standard (AES) algorithm instead.

```
#include <openssl/evp.h>
#include <stdlib.h>

void func(unsigned char *key, unsigned char *iv) {
    EVP_CIPHER_CTX *ctx = EVP_CIPHER_CTX_new();
    EVP_CIPHER_CTX_init(ctx);
    const EVP_CIPHER * ciph = EVP_aes_128_cbc();
    EVP_EncryptInit_ex(ctx, ciph, NULL, key, iv);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_CIPHER_WEAK_CIPHER`
Impact: Medium
CWE ID: 310, 326, 327

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Weak cipher mode

Encryption mode associated with the cipher context is weak

Description

Weak cipher mode occurs when you associate a weak block cipher mode with the cipher context.

The cipher mode that is especially flagged by this defect is the Electronic Code Book (ECB) mode.

Risk

The ECB mode does not support protection against dictionary attacks.

An attacker can decrypt your data even using brute force attacks.

Fix

Use a cipher mode more secure than ECB.

For instance, the Cipher Block Chaining (CBC) mode protects against dictionary attacks by:

- XOR-ing each block of data with the encrypted output from the previous block.
- XOR-ing the first block of data with a random initialization vector (IV).

Examples

Use of ECB Mode

```
#include <openssl/evp.h>
```

```
#include <stdlib.h>

void func(unsigned char *key, unsigned char *iv) {
    EVP_CIPHER_CTX *ctx = EVP_CIPHER_CTX_new();
    EVP_CIPHER_CTX_init(ctx);
    const EVP_CIPHER * ciph = EVP_aes_128_ecb();
    EVP_EncryptInit_ex(ctx, ciph, NULL, key, iv);
}
```

In this example, the routine `EVP_aes_128_ecb()` invokes the Advanced Encryption Standard (AES) algorithm in the Electronic Code Book (ECB) mode. The ECB mode does not support protection against dictionary attacks.

Correction — Use CBC Mode

One possible correction is to use the Cipher Block Chaining (CBC) mode instead.

```
#include <openssl/evp.h>
#include <stdlib.h>

void func(unsigned char *key, unsigned char *iv) {
    EVP_CIPHER_CTX *ctx = EVP_CIPHER_CTX_new();
    EVP_CIPHER_CTX_init(ctx);
    const EVP_CIPHER * ciph = EVP_aes_128_cbc();
    EVP_EncryptInit_ex(ctx, ciph, NULL, key, iv);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_CIPHER_WEAK_MODE`
Impact: Medium
CWE ID: 310, 326, 327

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Context initialized incorrectly for digest operation

Context used for digest operation is initialized for a different digest operation

Description

Context initialized incorrectly for digest operation occurs when you initialize an `EVP_MD_CTX` context object for a specific digest operation but use the context for a different operation.

For instance, you initialize the context for creating a message digest only.

```
ret = EVP_DigestInit(ctx, EVP_sha256())
```

However, you perform a final step for signing:

```
ret = EVP_SignFinal(&ctx, out, &out_len, pkey);
```

The error is shown only if the final step is not consistent with the initialization of the context. If the intermediate update steps are inconsistent, it does not trigger an error because the intermediate steps do not depend on the nature of the operation. For instance, `EVP_DigestUpdate` works identically to `EVP_SignUpdate`.

Risk

Mixing up different operations on the same context can lead to obscure code. It is difficult to determine at a glance whether the current object is used for message digest creation, signing, or verification. The mixup can also lead to a failure in the operation or unexpected message digest.

Fix

After you set up a context for a certain family of operations, use the context for only that family of operations. For instance, use these pairs of functions for initialization and final steps.

- `EVP_DigestInit` : `EVP_DigestFinal`
- `EVP_DigestInit_ex` : `EVP_DigestFinal_ex`
- `EVP_DigestSignInit` : `EVP_DigestSignFinal`

If you want to reuse an existing context object for a different family of operations, reinitialize the context.

Examples

Inconsistent Initial and Final Digest Operation

```
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
unsigned char *out_buf16;
unsigned int out_len16;

void func(unsigned char *src, size_t len){
  EVP_MD_CTX* ctx = EVP_MD_CTX_create();

  ret = EVP_SignInit_ex(ctx, EVP_sha256(), NULL);
  if (ret != 1) fatal_error();

  ret = EVP_SignUpdate(ctx, src, len);
  if (ret != 1) fatal_error();

  ret = EVP_DigestSignFinal(ctx, out_buf16, (size_t*) out_len16);

  if (ret != 1) fatal_error();
}
```

In this example, the context object is initialized for signing only with `EVP_SignInit` but the final step attempts to create a signed digest with `EVP_DigestSignFinal`.

Correction — Use One Family of Operations

One possible correction is to use the context object for signing only. Change the final step to `EVP_SignFinal` in keeping with the initialization step.

```
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
unsigned char *out_buf16;
unsigned int out_len16;

void corrected_cryptomdbadfunction(unsigned char *src, size_t len, EVP_PKEY* pkey){
  EVP_MD_CTX* ctx = EVP_MD_CTX_create();

  ret = EVP_SignInit_ex(ctx, EVP_sha256(), NULL);
  if (ret != 1) fatal_error();

  ret = EVP_SignUpdate(ctx, src, len);
  if (ret != 1) fatal_error();

  ret = EVP_SignFinal(ctx, out_buf16, &out_len16, pkey);
  if (ret != 1) fatal_error();
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_MD_BAD_FUNCTION`
Impact: Medium
CWE ID: 310, 353, 354, 372, 573, 664

See Also

`Nonsecure hash algorithm`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Nonsecure hash algorithm

Context used for message digest creation is associated with weak algorithm

Description

Nonsecure hash algorithm occurs when you use a cryptographic hash function that is proven to be weak against certain forms of attack.

The hash functions flagged by this checker include SHA-0, SHA-1, MD4, MD5, and RIPEMD-160. The checker detects the use of these hash functions in:

- Functions from the EVP API such as `EVP_DigestUpdate` or `EVP_SignUpdate`.
- Functions from the low level API such as `SHA1_Update` or `MD5_Update`.

Risk

You use a hash function to create a message digest from input data and thereby ensure integrity of your data. The hash functions flagged by this checker use algorithms with known weaknesses that an attacker can exploit. The attacks can comprise the integrity of your data.

Fix

Use a more secure hash function. For instance, use the later SHA functions such as SHA-224, SHA-256, SHA-384, and SHA-512.

Examples

Use of MD5 Algorithm

```
#include <openssl/evp.h>

#define fatal_error() exit(-1)
```

```
int ret;
unsigned char *out_buf;
unsigned int out_len;

void func(unsigned char *src, size_t len, EVP_PKEY* pkey){
  EVP_MD_CTX* ctx = EVP_MD_CTX_create();

  ret = EVP_SignInit_ex(ctx, EVP_md5(), NULL);
  if (ret != 1) fatal_error();

  ret = EVP_DigestUpdate(ctx,src,len);

  if (ret != 1) fatal_error();

  ret = EVP_SignFinal(ctx, out_buf, &out_len, pkey);
  if (ret != 1) fatal_error();
}
```

In this example, during initialization with `EVP_SignInit_ex`, the context object is associated with the weak hash function MD5. The checker flags the usage of this context in the update step with `EVP_DigestUpdate`.

Correction — Use SHA-2 Family Function

One possible correction is to use a hash function from the SHA-2 family, such as SHA-256.

```
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
unsigned char *out_buf;
unsigned int out_len;

void func(unsigned char *src, size_t len, EVP_PKEY* pkey){
  EVP_MD_CTX* ctx = EVP_MD_CTX_create();

  ret = EVP_SignInit_ex(ctx, EVP_sha256(), NULL);
  if (ret != 1) fatal_error();

  ret = EVP_SignUpdate(ctx, src, len);
  if (ret != 1) fatal_error();
```

```
  ret = EVP_SignFinal(ctx, out_buf, &out_len, pkey);
  if (ret != 1) fatal_error();
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: CRYPTO_MD_WEAK_HASH
Impact: Medium
CWE ID: 310, 327, 328, 353, 522

See Also

`Context initialized incorrectly for digest operation`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Context initialized incorrectly for cryptographic operation

Context used for public key cryptography operation is initialized for a different operation

Description

Context initialized incorrectly for cryptographic operation occurs when you initialize an `EVP_PKEY_CTX` object for a specific public key cryptography operation but use the object for a different operation.

For instance, you initialize the context for encryption.

```
ret = EVP_PKEY_encrypt_init(ctx);
```

However, you use the context for decryption without reinitializing the context.

```
ret = EVP_PKEY_decrypt(ctx, out, &out_len, in, in_len);
```

The checker detects if the context object used in these functions has been initialized by using the corresponding initialization functions: `EVP_PKEY_paramgen`, `EVP_PKEY_keygen`, `EVP_PKEY_encrypt`, `EVP_PKEY_verify`, `EVP_PKEY_verify_recover`,`EVP_PKEY_decrypt`, `EVP_PKEY_sign`, `EVP_PKEY_derive`,and `EVP_PKEY_derive_set_peer`.

Risk

Mixing up different operations on the same context can lead to obscure code. It is difficult to determine at a glance whether the current object is used for encryption, decryption, signature, or another operation. The mixup can also lead to a failure in the operation or unexpected ciphertext.

Fix

After you set up a context for a certain family of operations, use the context for only that family of operations.For instance, use these pairs of functions for initialization and usage of the `EVP_PKEY_CTX` context object.

- For encryption with `EVP_PKEY_encrypt`, initialize the context with `EVP_PKEY_encrypt_init`.
- For signature verification with `EVP_PKEY_verify`, initialize the context with `EVP_PKEY_verify_init`.
- For key generation with `EVP_PKEY_keygen`, initialize the context with `EVP_PKEY_keygen_init`.

If you want to reuse an existing context object for a different family of operations, reinitialize the context.

Examples

Encryption Using Context Initialized for Decryption

```
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
unsigned char *out_buf10;
size_t out_len10;
int func(unsigned char *src, size_t len, EVP_PKEY_CTX *ctx){
  if (ctx == NULL) fatal_error();

  ret = EVP_PKEY_decrypt_init(ctx);
  if (ret <= 0) fatal_error();
  return EVP_PKEY_encrypt(ctx, out_buf10, &out_len10, src, len);
}
```

In this example, the context is initialized for decryption but used for encryption.

Correction — Use One Family of Operations

One possible correction is to initialize the object for encryption.

```
#include <openssl/evp.h>

#define fatal_error() exit(-1)
```

```
int ret;
unsigned char *out_buf10;
size_t out_len10;
int func(unsigned char *src, size_t len, EVP_PKEY_CTX *ctx){
  if (ctx == NULL) fatal_error();

  ret = EVP_PKEY_encrypt_init(ctx);
  if (ret <= 0) fatal_error();
  return EVP_PKEY_encrypt(ctx, out_buf10, &out_len10, src, len);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_PKEY_INCORRECT_INIT`
Impact: Medium
CWE ID: 310, 325, 372, 573, 664

See Also

`Incorrect key for cryptographic algorithm|Missing parameters for key generation|Missing data for encryption, decryption or signing operation|Missing peer key|Missing private key|Missing public key|Nonsecure parameters for key generation`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Incorrect key for cryptographic algorithm

Public key cryptography operation is not supported by the algorithm used in context initialization

Description

Incorrect key for cryptographic algorithm occurs when you initialize a context object with a key for a specific algorithm but perform an operation that the algorithm does not support.

For instance, you initialize the context with a key for the DSA algorithm.

```
ret = EVP_PKEY_set1_DSA(pkey,dsa);
ctx = EVP_PKEY_CTX_new(pkey, NULL);
```

However, you use the context for encrypting data, an operation that the DSA algorithm does not support.

```
ret = EVP_PKEY_encrypt(ctx,out, &out_len, in, in_len);
```

Risk

If the algorithm does not support your cryptographic operation, you do not see the expected results. For instance, if you use the DSA algorithm for encryption, you might get unexpected ciphertext.

Fix

Use the algorithm that is appropriate for the cryptographic operation that you want to perform:

- Diffie-Hellman (DH): For key derivation.
- Digital Signature Algorithm (DSA): For signature.
- RSA: For encryption and signature.
- Elliptic curve (EC): For key derivation and signature.

Examples

Encryption with DSA Algorithm

```
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
unsigned char *out_buf;
size_t out_len;

int func(unsigned char *src, size_t len, DSA * dsa){
  EVP_PKEY_CTX *ctx;
  EVP_PKEY *pkey = NULL;

  pkey = EVP_PKEY_new();
  if(pkey == NULL) fatal_error();

  ret = EVP_PKEY_set1_DSA(pkey,dsa);
  if (ret <= 0) fatal_error();

  ctx = EVP_PKEY_CTX_new(pkey, NULL);
  if (ctx == NULL) fatal_error();

  ret = EVP_PKEY_encrypt_init(ctx);
  if (ret <= 0) fatal_error();
  return EVP_PKEY_encrypt(ctx, out_buf, &out_len, src, len);
}
```

In this example, the context object is initialized with a key associated with the DSA algorithm. However, the object is used for encryption, an operation that the DSA algorithm does not support.

Correction — Use RSA Algorithm

One possible correction is to initialize the context object with a key associated with the RSA algorithm.

```
#include <openssl/evp.h>
#include <openssl/rsa.h>
```

```
#define fatal_error() exit(-1)

int ret;
unsigned char *out_buf;
size_t out_len;

int func(unsigned char *src, size_t len, RSA * rsa){
  EVP_PKEY_CTX *ctx;
  EVP_PKEY *pkey = NULL;

  pkey = EVP_PKEY_new();
  if(pkey == NULL) fatal_error();

  ret = EVP_PKEY_set1_RSA(pkey,rsa);
  if (ret <= 0) fatal_error();

  ctx = EVP_PKEY_CTX_new(pkey, NULL); /* RSA key is set in the context */
  if (ctx == NULL) fatal_error();

  ret = EVP_PKEY_encrypt_init(ctx); /* Encryption operation is set in the context */
  if (ret <= 0) fatal_error();
  ret = EVP_PKEY_CTX_set_rsa_padding(ctx, RSA_PKCS1_OAEP_PADDING);
  if (ret <= 0) fatal_error();
  return EVP_PKEY_encrypt(ctx, out_buf, &out_len, src, len);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: CRYPTO_PKEY_INCORRECT_KEY
Impact: Medium
CWE ID: 310, 325, 573, 664

See Also

Context initialized incorrectly for cryptographic operation | Missing parameters for key generation | Missing data for encryption, decryption or signing operation | Missing peer key | Missing private key | Missing public key | Nonsecure parameters for key generation

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Missing data for encryption, decryption or signing operation

Data provided for public key cryptography operation is NULL or data length is zero

Description

Missing data for encryption, decryption or signing operation occurs when the data provided for an encryption, decryption, signing, or authentication operation is NULL or the data length is zero.

For instance, you unintentionally provide a NULL value for `in` or a zero value for `in_len` in this decryption operation:

```
ret = EVP_PKEY_decrypt(ctx, out, &out_len, in, in_len);
```

Or, you provide a NULL value for `md` or `sig`, or a zero value for `md_len` or `sig_len` in this verification operation:

```
ret = EVP_PKEY_verify(ctx, md, mdlen, sig, siglen);
```

Risk

With NULL data or zero length, the operation does not occur. The redundant operation often indicates a coding error.

Fix

Check the placement of the encryption, decryption, or signing operation. If the operation is intended to happen, make sure that the data provided is non-NULL. Set the data length to a nonzero value.

Examples

Zero Data Length for Signing Operation

```
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
int func(EVP_PKEY_CTX * ctx){
  if (ctx == NULL) fatal_error();
  unsigned char* sig = (unsigned char*) "0123456789";
  unsigned char* md = (unsigned char*) "0123456789";

  ret = EVP_PKEY_verify_init(ctx);
  if (ret <= 0) fatal_error();
  ret = EVP_PKEY_CTX_set_signature_md(ctx, EVP_sha256());
  if (ret <= 0) fatal_error();
  return EVP_PKEY_verify(ctx, sig, 0, md, 0);
}
```

In this example, the data lengths (third and fifth arguments to `EVP_PKEY_verify`) are zero. The operation fails.

Correction — Use Nonzero Data Length

One possible correction is to use a nonzero length for the signature and the data believed to be signed.

```
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
int func(EVP_PKEY_CTX * ctx){
  if (ctx == NULL) fatal_error();
  unsigned char* sig = (unsigned char*) "0123456789";
  unsigned char* md = (unsigned char*) "0123456789";

  ret = EVP_PKEY_verify_init(ctx);
  if (ret <= 0) fatal_error();
```

```
  ret = EVP_PKEY_CTX_set_signature_md(ctx, EVP_sha256());
  if (ret <= 0) fatal_error();
  return EVP_PKEY_verify(ctx, sig, 10, md, 10);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_PKEY_NO_DATA`
Impact: Medium
CWE ID: 310, 325, 372, 573

See Also

`Context initialized incorrectly for cryptographic operation|Incorrect key for cryptographic algorithm|Missing parameters for key generation|Missing peer key|Missing private key|Missing public key|Nonsecure parameters for key generation`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Missing parameters for key generation

Context used for key generation is associated with NULL parameters

Description

Missing parameters for key generation occurs when you perform a key generation step with a context object without first associating the object with required parameters.

For instance, you associate a `EVP_PKEY_CTX` context object with an empty `EVP_PKEY` object `params` before key generation :

```
EVP_PKEY * params = EVP_PKEY_new();
...
EVP_PKEY_CTX * ctx = EVP_PKEY_CTX_new(params, NULL);
...
EVP_PKEY_keygen(ctx, &pkey);
```

Risk

Without appropriate parameters, the key generation step does not occur. The redundant operation often indicates a coding error.

Fix

Check the placement of the key generation step. If the operation is intended, make sure that the parameters are set before key generation.

Certain algorithms use default parameters. For instance, if you specify the DSA algorithm when creating the `EVP_PKEY_CTX` object, a default key length of 1024 bits is used:

```
kctx = EVP_PKEY_CTX_new_id(EVP_PKEY_DSA, NULL);
```

Specifying the algorithm during context creation is sufficient to avoid this defect. Only if you use the Elliptic Curve (EC) algorithm, you must also specify the curve explicitly before key generation.

However, the default parameters can generate keys that are too weak for encryption. Weak parameters can trigger another defect. To change default parameters, use functions specific to the algorithm. For instance, to set parameters, you can use these functions:

- Diffie-Hellman (DH): Use `EVP_PKEY_CTX_set_dh_paramgen_prime_len` and `EVP_PKEY_CTX_set_dh_paramgen_generator`.
- Digital Signature Algorithm (DSA): Use `EVP_PKEY_CTX_set_dsa_paramgen_bits`.
- RSA: Use `EVP_PKEY_CTX_set_rsa_padding`, `EVP_PKEY_CTX_set_rsa_pss_saltlen`, `EVP_PKEY_CTX_set_rsa_rsa_keygen_bits`, and `EVP_PKEY_CTX_set_rsa_keygen_pubexp`.
- Elliptic curve (EC): Use `EVP_PKEY_CTX_set_ec_paramgen_curve_nid` and `EVP_PKEY_CTX_set_ec_param_enc`.

Examples

Empty Parameters During Key Generation

```
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
int func(EVP_PKEY *pkey){
  EVP_PKEY * params = EVP_PKEY_new();
  if (params == NULL) fatal_error();

  EVP_PKEY_CTX * ctx = EVP_PKEY_CTX_new(params, NULL);
  if (ctx == NULL) fatal_error();

  ret = EVP_PKEY_keygen_init(ctx);
  if (ret <= 0) fatal_error();
  return EVP_PKEY_keygen(ctx, &pkey);
}
```

In this example, the context object `ctx` is associated with an empty parameter object `params`. The context object does not have the required parameters for key generation.

Correction — Specify Algorithm During Context Creation

One possible correction is to specify an algorithm, such as RSA, during context creation. For stronger encryption, use 2048 bits for key length instead of the default 1024 bits.

```
#include <openssl/evp.h>
#include <openssl/rsa.h>

#define fatal_error() exit(-1)

int ret;
int func(EVP_PKEY *pkey){
  EVP_PKEY_CTX * ctx = EVP_PKEY_CTX_new_id(EVP_PKEY_RSA, NULL);
  if (ctx == NULL) fatal_error();

  ret = EVP_PKEY_keygen_init(ctx);
  if (ret <= 0) fatal_error();

  ret = EVP_PKEY_CTX_set_rsa_keygen_bits(ctx, 2048);
  if (ret <= 0) fatal_error();

  return EVP_PKEY_keygen(ctx, &pkey);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: CRYPTO_PKEY_NO_PARAMS
Impact: Medium
CWE ID: 310, 325, 372, 573

See Also

`Context initialized incorrectly for cryptographic operation` | `Incorrect key for cryptographic algorithm` | `Missing data for encryption, decryption or signing` | `Missing peer key` | `Missing private key` | `Missing public key` | `Nonsecure parameters for key generation`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Missing peer key

Context used for shared secret derivation is associated with NULL peer key or not associated with a peer key at all

Description

Missing peer key occurs when you use a context object for shared secret derivation but you have not previously associated the object with a non-NULL peer key.

For instance, you initialize the context object, and then use the object for shared secret derivation without an intermediate step where the object is associated with a peer key:

```
EVP_PKEY_derive_init(ctx);
/* Missing step for associating peer key with context */
ret = EVP_PKEY_derive(ctx, out_buf, &out_len);
```

The counterpart checker `Missing private key` checks for a private key in shared secret derivation.

Risk

Without a peer key, the shared secret derivation step does not occur. The redundant operation often indicates a coding error.

Fix

Check the placement of the shared secret derivation step. If the operation is intended, make sure that you have completed these steps prior to the operation:

- Generate a non-NULL peer key.

  For instance:

  ```
  EVP_PKEY* peerkey = NULL;
  EVP_PKEY_keygen(EVP_PKEY_CTX_new_id(EVP_PKEY_RSA, NULL), &peerkey);
  ```

- Associate a non-NULL context object with the peer key.

For instance:

```
EVP_PKEY_derive_set_peer(ctx,peerkey);
```

Examples

Missing Step for Associating Peer Key with Context

```
#include <stddef.h>
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
unsigned char *out_buf;
size_t out_len;

int func(EVP_PKEY *pkey){
  if (pkey == NULL) fatal_error();

  EVP_PKEY_CTX *ctx = EVP_PKEY_CTX_new(pkey, NULL);
  if (ctx == NULL) fatal_error();
  ret = EVP_PKEY_derive_init(ctx);
  if (ret <= 0) fatal_error();
  return EVP_PKEY_derive(ctx, out_buf, &out_len);
}
```

In this example, the context object `ctx` is associated with a private key but not a peer key. The `EVP_PKEY_derive` function uses this context object for shared secret derivation.

Correction — Set Peer Key in Context

One possible correction is to use the function `EVP_PKEY_derive_set_peer` and associate a peer key with the context object. Make sure that the peer key is non-NULL.

```
#include <stddef.h>
#include <openssl/evp.h>

#define fatal_error() exit(-1)
```

```
int ret;
unsigned char *out_buf;
size_t out_len;

int func(EVP_PKEY *pkey,  EVP_PKEY* peerkey){
  if (pkey == NULL) fatal_error();
  if (peerkey == NULL) fatal_error();

  EVP_PKEY_CTX *ctx = EVP_PKEY_CTX_new(pkey, NULL);
  if (ctx == NULL) fatal_error();
  ret = EVP_PKEY_derive_init(ctx);
  if (ret <= 0) fatal_error();
  ret = EVP_PKEY_derive_set_peer(ctx,peerkey);
  if (ret <= 0) fatal_error();
  return EVP_PKEY_derive(ctx, out_buf, &out_len);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: CRYPTO_PKEY_NO_PEER
Impact: Medium
CWE ID: 310, 320, 573, 664

See Also

`Context initialized incorrectly for cryptographic operation` | `Incorrect key for cryptographic algorithm` | `Missing parameters for key generation` | `Missing data for encryption, decryption or signing` | `Missing private key` | `Missing public key` | `Nonsecure parameters for key generation`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Missing private key

Context used for cryptography operation is associated with NULL private key or not associated with a private key at all

Description

Missing private key occurs when you use a context object for decryption, signature, or shared secret derivation but you have not previously associated the object with a non-NULL private key.

For instance, you initialize the context object with a NULL private key and use the object for decryption later.

```
ctx = EVP_PKEY_CTX_new(pkey, NULL);
...
ret = EVP_PKEY_decrypt_init(ctx);
...
ret = EVP_PKEY_decrypt(ctx, out, &out_len, in, in_len);
```

The counterpart checker `Missing public key` checks for a public key in encryption and authentication operations. The checker `Missing peer key` checks for a peer key in shared secret derivation.

Risk

Without a private key, the decryption, signature, or shared secret derivation step does not occur. The redundant operation often indicates a coding error.

Fix

Check the placement of the operation (decryption, signature, or shared secret derivation). If the operation is intended, make sure you have completed these steps prior to the operation:

- Generate a non-NULL private key.

  For instance:

```
EVP_PKEY *pkey = NULL;
kctx = EVP_PKEY_CTX_new_id(EVP_PKEY_RSA, NULL);

EVP_PKEY_keygen_init(kctx);
EVP_PKEY_CTX_set_rsa_keygen_bits(kctx, RSA_2048BITS);
EVP_PKEY_keygen(kctx, &pkey);
```

- Associate a non-NULL context object with the private key.

  For instance:

  ```
  ctx = EVP_PKEY_CTX_new(pkey, NULL);
  ```

  Note: If you use `EVP_PKEY_CTX_new_id` instead of `EVP_PKEY_CTX_new`, you are not associating the context object with a private key.

Examples

Missing Step for Associating Private Key with Context

```
#include <stddef.h>
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
unsigned char *out_buf;
size_t out_len;

int func(unsigned char *src, size_t len){
  EVP_PKEY_CTX *ctx = EVP_PKEY_CTX_new_id(EVP_PKEY_RSA, NULL);
  if (ctx == NULL) fatal_error();

  ret = EVP_PKEY_decrypt_init(ctx);
  if (ret <= 0) fatal_error();
  return EVP_PKEY_decrypt(ctx, out_buf, &out_len, src, len);
}
```

In this example, the context object `ctx` is initialized with `EVP_PKEY_CTX_new_id` instead of `EVP_PKEY_CTX_new`. The function `EVP_PKEY_CTX_new_id` does not associate the context object with a key. However, the `EVP_PKEY_decrypt` function uses this object for decryption.

Correction — Associate Private Key with Context During Initialization

One possible correction is to use the `EVP_PKEY_CTX_new` function for context initialization and associate a private key with the context object. In the following correction, the private key `pkey` is obtained from an external source and checked for NULL before use.

```
#include <stddef.h>
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
unsigned char *out_buf;
size_t out_len;

int func(unsigned char *src, size_t len, EVP_PKEY *pkey){
  if (pkey == NULL) fatal_error();

  EVP_PKEY_CTX *ctx = EVP_PKEY_CTX_new(pkey, NULL);
  if (ctx == NULL) fatal_error();

  ret = EVP_PKEY_decrypt_init(ctx);
  if (ret <= 0) fatal_error();
  return EVP_PKEY_decrypt(ctx, out_buf, &out_len, src, len);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_PKEY_NO_PRIVATE_KEY`
Impact: Medium
CWE ID: 310, 320, 573, 664

See Also

`Context initialized incorrectly for cryptographic operation` | `Incorrect key for cryptographic algorithm` | `Missing parameters for key`

`generation|Missing data for encryption, decryption or signing|Missing peer key|Missing public key|Nonsecure parameters for key generation`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Missing public key

Context used for cryptography operation is associated with NULL public key or not associated with a public key at all

Description

Missing public key occurs when you use a context object for encryption or signature authentication but you have not previously associated the object with a non-NULL public key.

For instance, you initialize the context object with a NULL public key and use the object for encryption later.

```
ctx = EVP_PKEY_CTX_new(pkey, NULL);
...
ret = EVP_PKEY_encrypt_init(ctx);
...
ret = EVP_PKEY_encrypt(ctx, out, &out_len, in, in_len);
```

The counterpart checker `Missing private key` checks for a private key in decryption and signature operations.

Risk

Without a public key, the encryption or signature authentication step does not happen. The redundant operation often indicates a coding error.

Fix

Check the placement of the operation (encryption or signature authentication). If the operation is intended to happen, make sure you have done these steps prior to the operation:

- You generated a non-NULL public key.

  For instance:

```
EVP_PKEY *pkey = NULL;
kctx = EVP_PKEY_CTX_new_id(EVP_PKEY_RSA, NULL);

EVP_PKEY_keygen_init(kctx);
EVP_PKEY_CTX_set_rsa_keygen_bits(kctx, RSA_2048BITS);
EVP_PKEY_keygen(kctx, &pkey);
```

- You associated a non-NULL context object with the public key.

  For instance:

  ```
  ctx = EVP_PKEY_CTX_new(pkey, NULL);
  ```

  Note: If you use `EVP_PKEY_CTX_new_id` instead of `EVP_PKEY_CTX_new`, you are not associating the context object with a public key.

Examples

Missing Step for Associating Private Key with Context

```
#include <stddef.h>
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
unsigned char *out_buf;
size_t out_len;

int func(unsigned char *src, size_t len){
  EVP_PKEY_CTX *ctx = EVP_PKEY_CTX_new_id(EVP_PKEY_RSA, NULL);
  if (ctx == NULL) fatal_error();

  ret = EVP_PKEY_encrypt_init(ctx);
  if (ret <= 0) fatal_error();
  return EVP_PKEY_encrypt(ctx, out_buf, &out_len, src, len);
}
```

In this example, the context object `ctx` is initialized with `EVP_PKEY_CTX_new_id` instead of `EVP_PKEY_CTX_new`. The function `EVP_PKEY_CTX_new_id` does not associate the context object with a key. However, the `EVP_PKEY_encrypt` function uses this object for decryption.

Correction — Associate Public Key with Context During Initialization

One possible correction is to use the `EVP_PKEY_CTX_new` function for context initialization and associate a public key with the context object. In the following correction, the public key `pkey` is obtained from an external source and checked for NULL before use.

```
#include <stddef.h>
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
unsigned char *out_buf;
size_t out_len;

int func(unsigned char *src, size_t len, EVP_PKEY *pkey){
  if (pkey == NULL) fatal_error();

  EVP_PKEY_CTX *ctx = EVP_PKEY_CTX_new(pkey, NULL);
  if (ctx == NULL) fatal_error();

  ret = EVP_PKEY_encrypt_init(ctx);
  if (ret <= 0) fatal_error();
  return EVP_PKEY_encrypt(ctx, out_buf, &out_len, src, len);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_PKEY_NO_PUBLIC_KEY`
Impact: Medium
CWE ID: 310, 320, 573, 664

See Also

`Context initialized incorrectly for cryptographic operation` | `Incorrect key for cryptographic algorithm` | `Missing parameters for key`

`generation|Missing data for encryption, decryption or signing|Missing peer key|Missing private key|Nonsecure parameters for key generation`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Nonsecure parameters for key generation

Context used for key generation is associated with weak parameters

Description

Nonsecure parameters for key generation occurs when you attempt key generation by using an EVP_PKEY_CTX context object that is associated with weak parameters. What constitutes a weak parameter depends on the public key algorithm used. In the DSA algorithm, a weak parameter can be the result of setting an insufficient parameter length.

For instance, you set the number of bits used for DSA parameter generation to 512 bits, and then use the parameters for key generation:

```
EVP_PKEY_CTX *pctx,*kctx;
EVP_PKEY *params, *pkey;

/* Initializations for parameter generation */
pctx = EVP_PKEY_CTX_new_id(EVP_PKEY_DSA, NULL);
params = EVP_PKEY_new();

/* Parameter generation */
ret = EVP_PKEY_paramgen_init(pctx);
ret = EVP_PKEY_CTX_set_dsa_paramgen_bits(pctx, KEYLEN_512BITS);
ret = EVP_PKEY_paramgen(pctx, &params);

/* Initializations for key generation */
kctx = EVP_PKEY_CTX_new(params, NULL);
pkey = EVP_PKEY_new();

/* Key generation */
ret = EVP_PKEY_keygen_init(kctx);
ret = EVP_PKEY_keygen(kctx, &pkey);
```

Risk

Weak parameters lead to keys that are not sufficiently strong for encryption and expose sensitive information to known ways of attack.

Fix

Depending on the algorithm, use these parameters:

- Diffie-Hellman (DH): Set the length of the DH prime parameter to 2048 bits.

  ```
  ret = EVP_PKEY_CTX_set_dh_paramgen_prime_len(pctx, 2048);
  ```

  Set the DH generator to 2 or 5.

  ```
  ret = EVP_PKEY_CTX_set_dh_paramgen_generator(pctx, 2);
  ```

- Digital Signature Algorithm (DSA): Set the number of bits used for DSA parameter generation to 2048 bits.

  ```
  ret = EVP_PKEY_CTX_set_dsa_paramgen_bits(pctx, 2048);
  ```

- RSA: Set the RSA key length to 2048 bits.

  ```
  ret = EVP_PKEY_CTX_set_rsa_keygen_bits(kctx, 2048);
  ```

- Elliptic curve (EC): Avoid using curves that are known to be broken, for instance, `X9_62_prime256v1`. Use, for instance, `sect239k1`.

  ```
  ret = EVP_PKEY_CTX_set_ec_paramgen_curve_nid(pctx, NID_sect239k1);
  ```

Examples

Insufficient Bits for RSA Key Generation

```
#include <stddef.h>
#include <openssl/rsa.h>
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
int func(EVP_PKEY *pkey){
  EVP_PKEY_CTX * ctx = EVP_PKEY_CTX_new_id(EVP_PKEY_RSA, NULL);
  if (ctx == NULL) fatal_error();

  ret = EVP_PKEY_keygen_init(ctx);
  if (ret <= 0) fatal_error();
```

```
  ret = EVP_PKEY_CTX_set_rsa_keygen_bits(ctx, 512);
  if (ret <= 0) fatal_error();
  return EVP_PKEY_keygen(ctx, &pkey);
}
```

In this example, the RSA key generation uses 512 bits, which makes the generated key vulnerable to attacks.

Correction — Use 2048 bits

Use 2048 bits for RSA key generation.

```
#include <stddef.h>
#include <openssl/rsa.h>
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
int func(EVP_PKEY *pkey){
  EVP_PKEY_CTX * ctx = EVP_PKEY_CTX_new_id(EVP_PKEY_RSA, NULL);
  if (ctx == NULL) fatal_error();

  ret = EVP_PKEY_keygen_init(ctx);
  if (ret <= 0) fatal_error();
  ret = EVP_PKEY_CTX_set_rsa_keygen_bits(ctx, 2048);
  if (ret <= 0) fatal_error();
  return EVP_PKEY_keygen(ctx, &pkey);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_PKEY_WEAK_PARAMS`
Impact: Medium
CWE ID: 310, 326, 327, 522

See Also

`Context initialized incorrectly for cryptographic operation` | `Incorrect key for cryptographic algorithm` | `Missing parameters for key generation` | `Missing data for encryption, decryption or signing` | `Missing peer key` | `Missing private key` | `Missing public key`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

External Websites

https://safecurves.cr.yp.to/
https://csrc.nist.gov/publications/detail/fips/186/4/final

Introduced in R2018a

Incompatible padding for RSA algorithm operation

Cryptography operation is not supported by the padding type set in context

Description

Incompatible padding for RSA algorithm operation occurs when you perform an RSA algorithm operation on a context object that is not compatible with the padding previously associated with the object.

For instance, you associate the OAEP padding scheme with a context object but later use the context for signature verification, an operation that the padding scheme does not support.

```
ret = EVP_PKEY_CTX_set_rsa_padding(ctx, RSA_PKCS1_OAEP_PADDING);
...
ret = EVP_PKEY_verify(ctx, out, out_len, in, in_len);
```

Risk

Padding schemes remove determinism from the RSA algorithm and protect RSA operations from certain kinds of attack.

When you use an incorrect padding scheme, the RSA operation can fail or result in unexpected ciphertext.

Fix

Before performing an RSA operation, associate the context object with a padding scheme that is compatible with the operation.

- Encryption: Use the OAEP padding scheme.

  For instance, use the `EVP_PKEY_CTX_set_rsa_padding` function with the argument `RSA_PKCS1_OAEP_PADDING` or the `RSA_padding_add_PKCS1_OAEP` function.

  ```
  ret = EVP_PKEY_CTX_set_rsa_padding(ctx, RSA_PKCS1_OAEP_PADDING);
  ```

You can also use the PKCS#1v1.5 or SSLv23 schemes. Be aware that these schemes are considered insecure.

You can then use functions such as `EVP_PKEY_encrypt` / `EVP_PKEY_decrypt` or `RSA_public_encrypt` / `RSA_private_decrypt` on the context.

- Signature: Use the RSA-PSS padding scheme.

  For instance, use the `EVP_PKEY_CTX_set_rsa_padding` function with the argument `RSA_PKCS1_PSS_PADDING`.

  ```
  ret = EVP_PKEY_CTX_set_rsa_padding(ctx, RSA_PKCS1_PSS_PADDING);
  ```

  You can also use the ANSI X9.31, PKCS#1v1.5, or SSLv23 schemes. Be aware that these schemes are considered insecure.

  You can then use functions such as the `EVP_PKEY_sign`-`EVP_PKEY_verify` pair or the `RSA_private_encrypt`-`RSA_public_decrypt` pair on the context.

If you perform two kinds of operation with the same context, after the first operation, reset the padding scheme in the context before the second operation.

Examples

OAEP Padding for Signature Operation

```
#include <stddef.h>
#include <openssl/rsa.h>

#define fatal_error() exit(-1)

int ret;
unsigned char *out_buf;

int func(unsigned char *src, size_t len, RSA* rsa){
  if (rsa == NULL) fatal_error();
  return RSA_private_encrypt(len, src, out_buf, rsa, RSA_PKCS1_OAEP_PADDING);
}
```

In this example, the function `RSA_private_encrypt` performs a signature operation by using the OAEP padding scheme, which supports encryption operations only.

Correction — Use Padding Scheme That Supports Signature

One possible correction is to use the RSA-PSS padding scheme. The corrected example uses the function `RSA_padding_add_PKCS1_PSS` to associate the padding scheme with the context.

```
#include <stddef.h>
#include <openssl/evp.h>
#include <openssl/rsa.h>

#define fatal_error() exit(-1)

int ret;
unsigned char *msg_pad;
unsigned char *out_buf;

int func(unsigned char *src, size_t len, RSA* rsa){
  if (rsa == NULL) fatal_error();

  ret = RSA_padding_add_PKCS1_PSS(rsa, msg_pad, src, EVP_sha256(), -2);
  if (ret <= 0) fatal_error();

  return RSA_private_encrypt(len, msg_pad, out_buf, rsa, RSA_NO_PADDING);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_RSA_BAD_PADDING`
Impact: Medium
CWE ID: 310, 372, 573, 664

See Also

`Missing blinding for RSA algorithm` | `Missing padding for RSA algorithm` | `Nonsecure RSA public exponent` | `Weak padding for RSA algorithm`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Nonsecure RSA public exponent

Context used in key generation is associated with low exponent value

Description

Nonsecure RSA public exponent occurs when you attempt RSA key generation by using a context object that is associated with a low public exponent.

For instance, you set a public exponent of 3 in the context object, and then use it for key generation.

```
/* Set public exponent */
ret = BN_dec2bn(&pubexp, "3");

/* Initialize context */
ctx = EVP_PKEY_CTX_new_id(EVP_PKEY_RSA, NULL);
pkey = EVP_PKEY_new();
ret = EVP_PKEY_keygen_init(kctx);

/* Set public exponent in context */
ret = EVP_PKEY_CTX_set_rsa_keygen_pubexp(ctx, pubexp);

/* Generate key */
ret = EVP_PKEY_keygen(kctx, &pkey);
```

Risk

A low RSA public exponent makes certain kinds of attacks more damaging, especially when a weak padding scheme is used or padding is not used at all.

Fix

It is recommended to use a public exponent of 65537. Using a higher public exponent can make the operations slower.

Examples

Using RSA Public Exponent of 3

```
#include <stddef.h>
#include <openssl/rsa.h>
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
int func(EVP_PKEY *pkey){
  BIGNUM* pubexp;
  EVP_PKEY_CTX* ctx;

  pubexp = BN_new();
  if (pubexp == NULL) fatal_error();
  ret = BN_set_word(pubexp, 3);
  if (ret <= 0) fatal_error();

  ctx = EVP_PKEY_CTX_new_id(EVP_PKEY_RSA, NULL);
  if (ctx == NULL) fatal_error();

  ret = EVP_PKEY_keygen_init(ctx);
  if (ret <= 0) fatal_error();
  ret = EVP_PKEY_CTX_set_rsa_keygen_bits(ctx, 2048);
  if (ret <= 0) fatal_error();
  ret = EVP_PKEY_CTX_set_rsa_keygen_pubexp(ctx, pubexp);
  if (ret <= 0) fatal_error();
  return EVP_PKEY_keygen(ctx, &pkey);
}
```

In this example, an RSA public exponent of 3 is associated with the context object `ctx`. The low exponent makes operations that use the generated key vulnerable to certain attacks.

Correction — Use Public Exponent of 65537

One possible correction is to use the recommended public exponent 65537.

```
#include <stddef.h>
```

```
#include <openssl/rsa.h>
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
int func(EVP_PKEY *pkey){
  BIGNUM* pubexp;
  EVP_PKEY_CTX* ctx;

  pubexp = BN_new();
  if (pubexp == NULL) fatal_error();
  ret = BN_set_word(pubexp, 65537);
  if (ret <= 0) fatal_error();

  ctx = EVP_PKEY_CTX_new_id(EVP_PKEY_RSA, NULL);
  if (ctx == NULL) fatal_error();

  ret = EVP_PKEY_keygen_init(ctx);
  if (ret <= 0) fatal_error();
  ret = EVP_PKEY_CTX_set_rsa_keygen_bits(ctx, 2048);
  if (ret <= 0) fatal_error();
  ret = EVP_PKEY_CTX_set_rsa_keygen_pubexp(ctx, pubexp);
  if (ret <= 0) fatal_error();
  return EVP_PKEY_keygen(ctx, &pkey);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: CRYPTO_RSA_LOW_EXPONENT
Impact: Medium
CWE ID: 310, 326, 327, 522

See Also

Incompatible padding for RSA algorithm operation|Missing blinding for RSA algorithm|Missing padding for RSA algorithm|Weak padding for RSA algorithm

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Missing blinding for RSA algorithm

Context used in decryption or signature verification is not blinded against timing attacks

Description

Missing blinding for RSA algorithm occurs when you do not enable blinding for an RSA context object before using the object for decryption or signature verification.

For instance, you do not turn on blinding in the context object `rsa` before this decryption step:

```
ret = RSA_public_decrypt(in_len, in, out, rsa, RSA_PKCS1_PADDING)
```

Risk

Without blinding, the time it takes for the cryptographic operation to be completed has a correlation with the key value. An attacker can gather information about the RSA key by measuring the time for completion. Blinding removes this correlation and protects the decryption or verification operation against timing attacks.

Fix

Before performing RSA decryption or signature verification, enable blinding.

```
ret = RSA_blinding_on(rsa, NULL);
```

Examples

Blinding Disabled Before Decryption

```
#include <stddef.h>
#include <openssl/rsa.h>
#include <openssl/evp.h>
```

```
#define fatal_error() exit(-1)

int ret;
unsigned char *out_buf;
int func(unsigned char *src, size_t len, RSA* rsa){
  if (rsa == NULL) fatal_error();

  RSA_blinding_off(rsa);
  return RSA_private_decrypt(len, src, out_buf, rsa, RSA_PKCS1_OAEP_PADDING);
}
```

In this example, blinding is disabled for the context object `rsa`. Decryption with this context object can be vulnerable to timing attacks.

Correction — Enable Blinding Before Decryption

One possible correction is to explicitly enable blinding before decryption. Even if blinding might be enabled previously or by default, explicitly enabling blinding ensures that the security of the current decryption step is not reliant on the caller of `func`.

```
#include <stddef.h>
#include <openssl/rsa.h>
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
unsigned char *out_buf;
int func(unsigned char *src, size_t len, RSA* rsa){
  if (rsa == NULL) fatal_error();

  ret = RSA_blinding_on(rsa, NULL);
  if (ret <= 0) fatal_error();
  return RSA_private_decrypt(len, src, out_buf, rsa, RSA_PKCS1_OAEP_PADDING);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_RSA_NO_BLINDING`

Impact: Medium
CWE ID: 310, 326, 573

See Also

`Incompatible padding for RSA algorithm operation` | `Missing padding for RSA algorithm` | `Nonsecure RSA public exponent` | `Weak padding for RSA algorithm`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Missing padding for RSA algorithm

Context used in encryption or signing operation is not associated with any padding

Description

Missing padding for RSA algorithm occurs when you perform RSA encryption or signature by using a context object without associating the object with a padding scheme.

For instance, you perform encryption by using a context object that was initially not associated with a specific padding.

```
ret = EVP_PKEY_CTX_set_rsa_padding(ctx, RSA_NO_PADDING);
...
ret = EVP_PKEY_encrypt(ctx, out, &out_len, in, in_len)
```

Risk

Padding schemes remove determinism from the RSA algorithm and protect RSA operations from certain kinds of attack. Padding ensures that a given message does not lead to the same ciphertext each time it is encrypted. Without padding, an attacker can launch chosen-plaintext attacks against the cryptosystem.

Fix

Before performing an RSA operation, associate the context object with a padding scheme that is compatible with the operation.

- Encryption: Use the OAEP padding scheme.

  For instance, use the `EVP_PKEY_CTX_set_rsa_padding` function with the argument `RSA_PKCS1_OAEP_PADDING` or the `RSA_padding_add_PKCS1_OAEP` function.

  ```
  ret = EVP_PKEY_CTX_set_rsa_padding(ctx, RSA_PKCS1_OAEP_PADDING);
  ```

  You can also use the PKCS#1v1.5 or SSLv23 schemes. Be aware that these schemes are considered insecure.

You can then use functions such as `EVP_PKEY_encrypt` / `EVP_PKEY_decrypt` or `RSA_public_encrypt` / `RSA_private_decrypt` on the context.

- Signature: Use the RSA-PSS padding scheme.

  For instance, use the `EVP_PKEY_CTX_set_rsa_padding` function with the argument `RSA_PKCS1_PSS_PADDING`.

  ```
  ret = EVP_PKEY_CTX_set_rsa_padding(ctx, RSA_PKCS1_PSS_PADDING);
  ```

  You can also use the ANSI X9.31, PKCS#1v1.5, or SSLv23 schemes. Be aware that these schemes are considered insecure.

  You can then use functions such as the `EVP_PKEY_sign`-`EVP_PKEY_verify` pair or the `RSA_private_encrypt`-`RSA_public_decrypt` pair on the context.

If you perform two kinds of operation with the same context, after the first operation, reset the padding scheme in the context before the second operation.

Examples

Encryption Without Padding

```
#include <stddef.h>
#include <openssl/rsa.h>
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
unsigned char *out_buf;
size_t out_len;


int func(unsigned char *src, size_t len){
  EVP_PKEY_CTX *ctx;
  EVP_PKEY* pkey;

  /* Key generation */
  ctx = EVP_PKEY_CTX_new_id(EVP_PKEY_RSA,NULL);
  if (ctx == NULL) fatal_error();
```

```
  ret = EVP_PKEY_keygen_init(ctx);
  if (ret <= 0) fatal_error();
  ret = EVP_PKEY_CTX_set_rsa_keygen_bits(ctx, 2048);
  if (ret <= 0) fatal_error();
  ret = EVP_PKEY_keygen(ctx, &pkey);
  if (ret <= 0) fatal_error();

  /* Encryption */
  EVP_PKEY_CTX_free(ctx);
  ctx = EVP_PKEY_CTX_new(pkey,NULL);
  if (ctx == NULL) fatal_error();

  ret = EVP_PKEY_encrypt_init(ctx);
  if (ret <= 0) fatal_error();
  return EVP_PKEY_encrypt(ctx, out_buf, &out_len, src, len);
}
```

In this example, before encryption with `EVP_PKEY_encrypt`, a specific padding is not associated with the context object `ctx`.

Correction — Set Padding in Context Before Encryption

One possible correction is to set the OAEP padding scheme in the context.

```
#include <stddef.h>
#include <openssl/rsa.h>
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
unsigned char *out_buf;
size_t out_len;


int func(unsigned char *src, size_t len){
  EVP_PKEY_CTX *ctx;
  EVP_PKEY* pkey;

  /* Key generation */
  ctx = EVP_PKEY_CTX_new_id(EVP_PKEY_RSA,NULL);
  if (ctx == NULL) fatal_error();
```

```
  ret = EVP_PKEY_keygen_init(ctx);
  if (ret <= 0) fatal_error();
  ret = EVP_PKEY_CTX_set_rsa_keygen_bits(ctx, 2048);
  if (ret <= 0) fatal_error();
  ret = EVP_PKEY_keygen(ctx, &pkey);
  if (ret <= 0) fatal_error();

  /* Encryption */
  EVP_PKEY_CTX_free(ctx);
  ctx = EVP_PKEY_CTX_new(pkey,NULL);
  if (ctx == NULL) fatal_error();

  ret = EVP_PKEY_encrypt_init(ctx);
  ret = EVP_PKEY_CTX_set_rsa_padding(ctx, RSA_PKCS1_OAEP_PADDING);
  if (ret <= 0) fatal_error();
  if (ret <= 0) fatal_error();
  return EVP_PKEY_encrypt(ctx, out_buf, &out_len, src, len);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_RSA_NO_PADDING`
Impact: Medium
CWE ID: 310, 326, 327, 780

See Also

`Incompatible padding for RSA algorithm operation` | `Missing blinding for RSA algorithm` | `Nonsecure RSA public exponent` | `Weak padding for RSA algorithm`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Weak padding for RSA algorithm

Context used in encryption or signing operation is associated with insecure padding type

Description

Weak padding for RSA algorithm occurs when you perform RSA encryption or signature by using a context object that was previously associated with a weak padding scheme.

For instance, you perform encryption by using a context object that is associated with the PKCS#1v1.5 padding scheme. The scheme is considered insecure and has already been broken.

```
ret = EVP_PKEY_CTX_set_rsa_padding(ctx, RSA_PKCS1_PADDING);
...
ret = EVP_PKEY_encrypt(ctx, out, &out_len, in, in_len)
```

Risk

Padding schemes remove determinism from the RSA algorithm and protect RSA operations from certain kinds of attacks. Padding schemes such as PKCS#1v1.5, ANSI X9.31, and SSLv23 are known to be vulnerable. Do not use these padding schemes for encryption or signature operations.

Fix

Before performing an RSA operation, associate the context object with a strong padding scheme.

- Encryption: Use the OAEP padding scheme.

  For instance, use the `EVP_PKEY_CTX_set_rsa_padding` function with the argument `RSA_PKCS1_OAEP_PADDING` or the `RSA_padding_add_PKCS1_OAEP` function.

  ```
  ret = EVP_PKEY_CTX_set_rsa_padding(ctx, RSA_PKCS1_OAEP_PADDING);
  ```

  You can then use functions such as `EVP_PKEY_encrypt` / `EVP_PKEY_decrypt` or `RSA_public_encrypt` / `RSA_private_decrypt` on the context.

- Signature: Use the RSA-PSS padding scheme.

  For instance, use the `EVP_PKEY_CTX_set_rsa_padding` function with the argument `RSA_PKCS1_PSS_PADDING`.

  ```
  ret = EVP_PKEY_CTX_set_rsa_padding(ctx, RSA_PKCS1_PSS_PADDING);
  ```

  You can then use functions such as the `EVP_PKEY_sign`-`EVP_PKEY_verify` pair or the `RSA_private_encrypt`-`RSA_public_decrypt` pair on the context.

Examples

Encryption with PKCS#1v1.5 Padding

```
#include <stddef.h>
#include <openssl/rsa.h>
#include <openssl/evp.h>

#define fatal_error() exit(-1)

int ret;
unsigned char *out_buf;

int func(unsigned char *src, size_t len, RSA* rsa){
  if (rsa == NULL) fatal_error();

  return RSA_public_encrypt(len, src, out_buf, rsa, RSA_PKCS1_PADDING);
}
```

In this example, the PKCS#1v1.5 padding scheme is used in the encryption step.

Correction — Use OAEP Padding Scheme

Use the OAEP padding scheme for stronger encryption.

```
#include <stddef.h>
#include <openssl/rsa.h>
#include <openssl/evp.h>

#define fatal_error() exit(-1)
```

```
int ret;
unsigned char *out_buf;

int func(unsigned char *src, size_t len, RSA* rsa){
  if (rsa == NULL) fatal_error();

  return RSA_public_encrypt(len, src, out_buf, rsa, RSA_PKCS1_OAEP_PADDING);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: CRYPTO_RSA_WEAK_PADDING
Impact: Medium
CWE ID: 310, 326, 327, 780

See Also

Incompatible padding for RSA algorithm operation|Missing blinding for RSA algorithm|Missing padding for RSA algorithm|Nonsecure RSA public exponent

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Nonsecure SSL/TLS protocol

Context used for handling SSL/TLS connections is associated with weak protocol

Description

Nonsecure SSL/TLS protocol occurs when you do not disable nonsecure protocols in an `SSL_CTX` or `SSL` context object before using the object for handling SSL/TLS connections.

For instance, you disable the protocols SSL2.0 and TLS1.0 but forget to disable the protocol SSL3.0, which is also considered weak.

```
/* Create and configure context */
ctx = SSL_CTX_new(SSLv23_method());
SSL_CTX_set_options(ctx, SSL_OP_NO_SSLv2|SSL_OP_NO_TLSv1);

/* Use context to handle connection */
ssl = SSL_new(ctx);
SSL_set_fd(ssl, NULL);
ret = SSL_connect(ssl);
```

Risk

The protocols SSL2.0, SSL3.0, and TLS1.0 are considered weak in the cryptographic community. Using one of these protocols can expose your connections to cross-protocol attacks. The attacker can decrypt an RSA ciphertext without knowing the RSA private key.

Fix

Disable the nonsecure protocols in the context object before using the object to handle connections.

```
/* Create and configure context */
ctx = SSL_CTX_new(SSLv23_method());
SSL_CTX_set_options(ctx, SSL_OP_NO_SSLv2|SSL_OP_NO_SSLv3|SSL_OP_NO_TLSv1);
```

Examples

Nonsecure Protocols Not Disabled

```
#include <stdlib.h>
#include <stdio.h>
#include <unistd.h>
#include <sys/socket.h>
#include <arpa/inet.h>
#include <openssl/ssl.h>
#include <openssl/err.h>


#define fatal_error() exit(-1)

int ret;
int func(){
  SSL_CTX *ctx;
  SSL *ssl;

  SSL_library_init();

  /* context configuration */
  ctx = SSL_CTX_new(SSLv23_client_method());
  if (ctx==NULL) fatal_error();

  ret = SSL_CTX_use_certificate_file(ctx, "cert.pem", SSL_FILETYPE_PEM);
  if (ret <= 0) fatal_error();

  ret = SSL_CTX_load_verify_locations(ctx, NULL, "ca/path");
  if (ret <= 0) fatal_error();

  /* Handle connection */
  ssl = SSL_new(ctx);
  if (ssl==NULL) fatal_error();
  SSL_set_fd(ssl, NULL);

  return SSL_connect(ssl);
}
```

In this example, the protocols SSL2.0, SSL3.0, and TLS1.0 are not disabled in the context object before the object is used for a new connection.

Correction — Disable Nonsecure Protocols

Disable nonsecure protocols before using the objects for a new connection. Use the function `SSL_CTX_set_options` to disable the protocols SSL2.0, SSL3.0, and TLS1.0.

```
#include <stdlib.h>
#include <stdio.h>
#include <unistd.h>
#include <sys/socket.h>
#include <arpa/inet.h>
#include <openssl/ssl.h>
#include <openssl/err.h>


#define fatal_error() exit(-1)

int ret;
int func(){
  SSL_CTX *ctx;
  SSL *ssl;

  SSL_library_init();

  /* context configuration */
  ctx = SSL_CTX_new(SSLv23_client_method());
  if (ctx==NULL) fatal_error();

  SSL_CTX_set_options(ctx, SSL_OP_NO_SSLv2|SSL_OP_NO_SSLv3|SSL_OP_NO_TLSv1);

  ret = SSL_CTX_use_certificate_file(ctx, "cert.pem", SSL_FILETYPE_PEM);
  if (ret <= 0) fatal_error();

  ret = SSL_CTX_load_verify_locations(ctx, NULL, "ca/path");
  if (ret <= 0) fatal_error();

  /* Handle connection */
  ssl = SSL_new(ctx);
  if (ssl==NULL) fatal_error();
  SSL_set_fd(ssl, NULL);

  return SSL_connect(ssl);
}
```

Result Information

Group: Cryptography
Language: C | C++
Default: Off
Command-Line Syntax: `CRYPTO_SSL_WEAK_PROTOCOL`
Impact: Medium
CWE ID: 310, 327, 522, 693

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

C++ reference type qualified with const or volatile

Reference type declared with a redundant `const` or `volatile` qualifier

Description

C++ reference type qualified with const or volatile occurs when a variable with reference type is declared with the `const` or `volatile` qualifier, for instance:

```
char &const c;
```

Risk

The C++14 Standard states that `const` or `volatile` qualified references are ill formed (unless they are introduced through a `typedef`, in which case they are ignored). For instance, a reference to one variable cannot be made to refer to another variable. Therefore, using the `const` qualifier is not required for a variable with a reference type.

Often the use of these qualifiers indicate a coding error. For instance, you meant to declare a reference to a `const`-qualified type:

```
char const &c;
```

but instead declared a `const`-qualified reference:

```
char &const c;
```

If your compiler does not detect the error, you can see unexpected results. For instance, you might expect `c` to be immutable but see a different value of `c` compared to its value at declaration.

Fix

See if the `const` or `volatile` qualifier is incorrectly placed. For instance, see if you wanted to refer to a `const`-qualified type and entered:

```
char &const c;
```

instead of:

```
char const &c;
```

If the qualifier is incorrectly placed, fix the error. Place the `const` or `volatile`qualifier before the & operator. Otherwise, remove the redundant qualifier.

Examples

`const`-Qualified Reference Type

```
int func (int &const iRef) {
    iRef++;
    return iRef%2;
}
```

In this example, `iRef` is a `const`-qualified reference type. Since `iRef` cannot refer to another variable, the `const` qualifier is redundant.

Correction — Remove `const` Qualifier

Remove the redundant `const` qualifier. Since `iRef` is modified in `func`, it is not meant to refer to a `const`-qualified variable. Moving the `const` qualifier before & will cause a compilation error.

```
int func (int &iRef) {
    iRef++;
    return iRef%2;
}
```

Correction — Fix Placement of `const` Qualifier

If you do not identify to modify `iRef` in `func`, declare `iRef` as a reference to a `const`-qualified variable. Place the `const` qualifier before the & operator. Make sure you do not modify `iRef` in `func`.

```
int func (int const &iRef) {
    return (iRef+1)%2;
}
```

Result Information

Group: Good practice
Language: C++
Default: Off
Command-Line Syntax: `CV_QUALIFIED_REFERENCE_TYPE`
Impact: Low

See Also

`C++ reference to const-qualified type with subsequent modification|Qualifier removed in conversion|Unreliable cast of function pointer|Unreliable cast of pointer|Writing to const qualified object`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2019a

Vulnerable permission assignments

Argument gives read/write/search permissions to external users

Description

Vulnerable permission assignments looks at functions that can change file permissions, such as `chmod`, `umask`, `creat`, or `open`. If the specified permissions allow unintended actors to modify or read the resource, Bug Finder flags the functions as a defect.

Risk

If you give outside users or outside groups a wider range or permissions than required, you potentially expose your sensitive information and your modifications. This defect is especially dangerous for permissions related to:

- Program configurations
- Program executions
- Sensitive user data

Fix

Set your permissions so that the user (`u`) has more permissions than the group (`g`), and so the group has more permissions than other users (`o`), or `u >= g >= o`.

Examples

Create File with Other Permissions

```
#include <unistd.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <fcntl.h>
```

```
void bug_dangerouspermissions(const char * log_path) {
    mode_t mode = S_IROTH | S_IXOTH | S_IWOTH;
    int fd = creat(log_path, mode);

    if (fd) {
        write(fd, "Hello\n", 6);
    }
    close(fd);
    unlink(log_path);
}
```

In this example, the `log_path` file is created with more rights for the other outside users, than the current user. The permissions are `---------rwx`.

Correction — Modify User Permissions

One possible correction is to modify the user permissions for the file. In this correction, the user has read/write/execute permissions, but other users do not.

```
#include <unistd.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <fcntl.h>

void corrected_dangerouspermissions(const char * log_path) {
    mode_t mode = S_IRUSR | S_IXUSR | S_IWUSR;
    int fd = creat(log_path, mode);

    if (fd) {
        write(fd, "Hello\n", 6);
    }
    close(fd);
    unlink(log_path);
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `DANGEROUS_PERMISSIONS`
Impact: Medium

CWE ID: 732, 922

See Also

`Umask used with chmod-style arguments`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Use of dangerous standard function

Dangerous functions cause possible buffer overflow in destination buffer

Description

The **Use of dangerous standard function** check highlights uses of functions that are inherently dangerous or potentially dangerous given certain circumstances. The following table lists possibly dangerous functions, the risks of using each function, and what function to use instead.

Dangerous Function	Risk Level	Safer Function
`gets`	Inherently dangerous — You cannot control the length of input from the console.	`fgets`
`cin`	Inherently dangerous — You cannot control the length of input from the console.	Avoid or prefaces calls to `cin` with `cin.width`.
`strcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`strncpy`
`stpcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`stpncpy`
`lstrcpy` or `StrCpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`StringCbCopy`, `StringCchCopy`, `strncpy`, `strcpy_s`, or `strlcpy`

Dangerous Function	Risk Level	Safer Function
`strcat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`strncat`, `strlcat`, or `strcat_s`
`lstrcat` or `StrCat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`StringCbCat`, `StringCchCat`, `strncay`, `strcat_s`, or `strlcat`
`wcpcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`wcpncpy`
`wcscat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`wcsncat`, `wcslcat`, or `wcncat_s`
`wcscpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`wcsncpy`
`sprintf`	Possibly dangerous — If the output length depends on unknown lengths or values, buffer overflow can occur.	`snprintf`
`vsprintf`	Possibly dangerous — If the output length depends on unknown lengths or values, buffer overflow can occur.	`vsnprintf`

Risk

These functions can cause buffer overflow, which attackers can use to infiltrate your program.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Using `sprintf`

```
#include <stdio.h>
#include <string.h>
#include <iostream>

#define BUFF_SIZE 128


int dangerous_func(char *str)
{
    char dst[BUFF_SIZE];
    int r = 0;

    if (sprintf(dst, "%s", str) == 1)
    {
        r += 1;
        dst[BUFF_SIZE-1] = '\0';
    }

    return r;
}
```

This example function uses `sprintf` to copy the string `str` to `dst`. However, if `str` is larger than the buffer, `sprintf` can cause buffer overflow.

Correction — Use `snprintf` with Buffer Size

One possible correction is to use `snprintf` instead and specify a buffer size.

```
#include <stdio.h>
#include <string.h>
#include <iostream>

#define BUFF_SIZE 128


int dangerous_func(char *str)
{
    char dst[BUFF_SIZE];
    int r = 0;

    if (snprintf(dst, sizeof(dst), "%s", str) == 1)
    {
        r += 1;
        dst[BUFF_SIZE-1] = '\0';
    }

    return r;
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `DANGEROUS_STD_FUNC`
Impact: Low
CWE ID: 242, 676

See Also

`Use of obsolete standard function` | `Unsafe standard function` | `Invalid use of standard library string routine`

Topics

“Interpret Polyspace Bug Finder Access Results”

“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Mismatch between data length and size

Data size argument is not computed from actual data length

Description

Mismatch between data length and size looks for memory copying functions such as `memcpy`, `memset`, or `memmove`. If you do not control the length argument and data buffer argument properly, Bug Finder raises a defect.

Risk

If an attacker can manipulate the data buffer or length argument, the attacker can cause buffer overflow by making the actual data size smaller than the length.

This mismatch in length allows the attacker to copy memory past the data buffer to a new location. If the extra memory contains sensitive information, the attacker can now access that data.

This defect is similar to the SSL Heartbleed bug.

Fix

When copying or manipulating memory, compute the length argument directly from the data so that the sizes match.

Examples

Copy Buffer of Data

```
#include <stdlib.h>
#include <string.h>

typedef struct buf_mem_st {
    char *data;
```

```
    size_t max;     /* size of buffer */
} BUF_MEM;

extern BUF_MEM beta;

int cpy_data(BUF_MEM *alpha)
{
    BUF_MEM *os = alpha;
    int num, length;

    if (alpha == 0x0) return 0;
    num = 0;

    length = *(unsigned short *)os->data;
    memcpy(&(beta.data[num]), os->data + 2, length);

    return(1);
}
```

This function copies the buffer `alpha` into a buffer `beta`. However, the `length` variable is not related to `data+2`.

Correction — Check Buffer Length

One possible correction is to check the length of your buffer against the maximum value minus 2. This check ensures that you have enough space to copy the data to the `beta` structure.

```
#include <stdlib.h>
#include <string.h>

typedef struct buf_mem_st {
    char *data;
    size_t max;     /* size of buffer */
} BUF_MEM;

extern BUF_MEM beta;

int cpy_data(BUF_MEM *alpha)
{
    BUF_MEM *os = alpha;
    int num, length;

    if (alpha == 0x0) return 0;
```

```
    num = 0;

    length = *(unsigned short *)os->data;
    if (length<(os->max -2)) {
        memcpy(&(beta.data[num]), os->data + 2, length);
    }

    return(1);

}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: DATA_LENGTH_MISMATCH
Impact: Medium
CWE ID: 130, 240

See Also

Copy of overlapping memory

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Data race

Multiple tasks perform unprotected nonatomic operations on shared variable

Description

Data race occurs when:

1. Multiple tasks perform unprotected operations on a shared variable.
2. At least one task performs a write operation.
3. At least one operation is nonatomic. For data race on both atomic and nonatomic operations, see `Data race including atomic operations`.

   See the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**. For more information, see the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Data race can result in unpredictable values of the shared variable because you do not control the order of the operations in different tasks.

Data races between two write operations are more serious than data races between a write and read operation. Two write operations can interfere with each other and result in indeterminate values. To identify write-write conflicts, use the filters on the **Detail** column of the **Results List** pane. For these conflicts, the **Detail** column shows the additional line:

```
Variable value may be altered by write-write concurrent access.
```

See “Filter and Sort Results”.

Fix

To fix this defect, protect the operations on the shared variable using critical sections, temporal exclusion or another means. See the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

To identify existing protections that you can reuse, see the table and graphs associated with the result. The table shows each pair of conflicting calls. The **Access Protections** column shows existing protections on the calls. To see the function call sequence leading to the conflicts, click the  icon. For an example, see below.

Examples

Unprotected Operation on Global Variable from Multiple Tasks

```
int var;
void begin_critical_section(void);
void end_critical_section(void);

void increment(void) {
    var++;
}

void task1(void)  {
      increment();
}

void task2(void)  {
      increment();
}

void task3(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}
```

In this example, to emulate multitasking behavior, specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	task1 task2 task3	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section	end_critical_section

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
  -entry-points task1,task2,task3
  -critical-section-begin begin_critical_section:cs1
  -critical-section-end end_critical_section:cs1
```

In this example, the tasks `task1`, `task2`, and `task3` call the function `increment`. `increment` contains the operation `var++` that can involve multiple machine instructions including:

- Reading `var`.
- Writing an increased value to `var`.

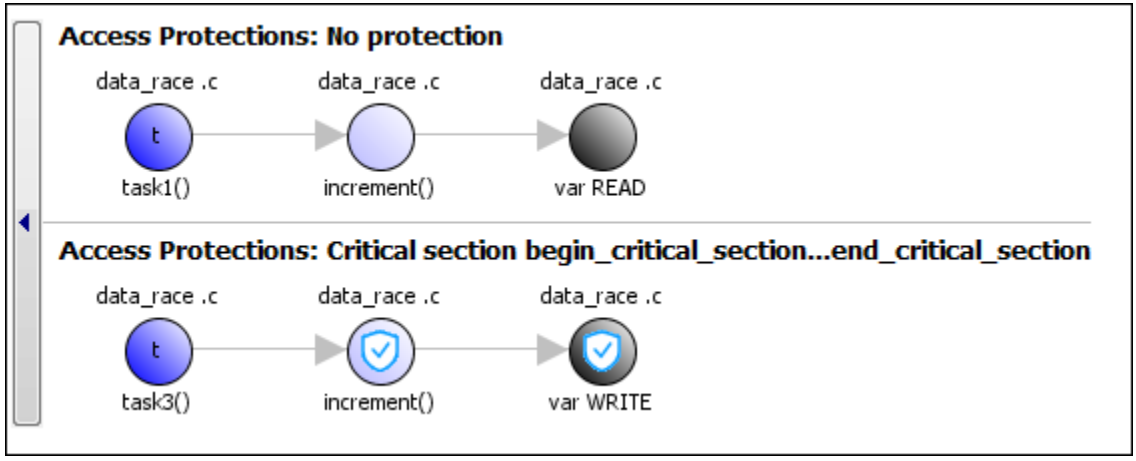
These machine instructions, when executed from `task1` and `task2`, can occur concurrently in an unpredictable sequence. For example, reading `var` from `task1` can occur either before or after writing to `var` from `task2`. Therefore the value of `var` can be unpredictable.

Though `task3` calls `increment` inside a critical section, other tasks do not use the same critical section. The operations in the critical section of `task3` are not mutually exclusive with operations in other tasks.

Therefore, the three tasks are operating on a shared variable without common protection. In your result details, you see each pair of conflicting function calls.

	Access	Access Protections	Task	File
	Read	No protection	task1()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	No protection	task2()	data_race .c
	Read	No protection	task1()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	**Critical section begin_critical_section...end_critical_section**	task3()	data_race .c
	Read	No protection	task2()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	**Critical section begin_critical_section...end_critical_section**	task3()	data_race .c

If you click the  icon, you see the function call sequence starting from the entry point to the read or write operation. You also see that the operation starting from `task3` is in a critical section. The **Access Protections** entry shows the lock and unlock function that begin and end the critical section. In this example, you see the functions `begin_critical_section` and `end_critical_section`.



Correction — Place Operation in Critical Section

One possible correction is to place the operation in critical section. You can implement the critical section in multiple ways. For instance:

- You can place `var++` in a critical section. When `task1` enters its critical section, the other tasks cannot enter their critical sections until `task1` leaves its critical section. The operation `var++` from the three tasks cannot interfere with each other.

To implement the critical section, in the function `increment`, place the operation `var ++` between calls to `begin_critical_section` and `end_critical_section`.

```
int var;

void begin_critical_section(void);
void end_critical_section(void);

void increment(void) {
      begin_critical_section();
      var++;
      end_critical_section();
}

void task1(void)  {
      increment();
}

void task2(void)  {
      increment();
}

void task3(void)  {
      increment();
}
```

- You can place the call to `increment` in the same critical section in the three tasks. When `task1` enters its critical section, the other tasks cannot enter their critical sections until `task1` leaves its critical section. The calls to `increment` from the three tasks cannot interfere with each other.

  To implement the critical section, in each of the three tasks, call `increment` between calls to `begin_critical_section` and `end_critical_section`.

```
int var;

void begin_critical_section(void);
void end_critical_section(void);
```

```
void increment(void) {
      var++;
}

void task1(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}

void task2(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}

void task3(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}
```

Correction — Make Tasks Temporally Exclusive

Another possible correction is to make the tasks, `task1`, `task2` and `task3`, temporally exclusive. Temporally exclusive tasks cannot execute concurrently.

On the **Configuration** pane, specify the following additional options:

Option	Value
`Temporally exclusive tasks (-temporal-exclusions-file)`	`task1 task2 task3`

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
    -temporal-exclusions-file "C:\exclusions_file.txt"
```

where the file `C:\exclusions_file.txt` has the following line:

```
task1 task2 task3
```

Unprotected Operation in Threads Created with `pthread_create`

```
#include <pthread.h>

pthread_mutex_t count_mutex;
long long count;


void* increment_count(void* args)
{
    count = count + 1;
    return NULL;
}

void* set_count(void *args)
{
    long long c;
    c = count;
    return NULL;
}

int main(void)
{
    pthread_t thread_increment;
    pthread_t thread_get;

    pthread_create(&thread_increment, NULL, increment_count, NULL);
    pthread_create(&thread_get, NULL, set_count, NULL);

    pthread_join(thread_get, NULL);
    pthread_join(thread_increment, NULL);

    return 1;
}
```

In this example, Bug Finder detects the creation of separate threads with `pthread_create`. The **Data race** defect is raised because the operation `count = count + 1` in the thread with id `thread_increment` conflicts with the operation `c = count` in the thread with id `thread_get`. The variable `count` is accessed in multiple threads without a common protection.

The two conflicting operations are nonatomic. The operation `c = count` is nonatomic on 32-bit targets. See the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

Correction — Protect Operations with `pthread_mutex_lock` and `pthread_mutex_unlock` Pair

To prevent concurrent access on the variable `count`, protect operations on `count` with a critical section. Use the functions `pthread_mutex_lock` and `pthread_mutex_unlock` to implement the critical section.

```
#include <pthread.h>

pthread_mutex_t count_mutex;
long long count;


void* increment_count(void* args)
{
    pthread_mutex_lock(&count_mutex);
    count = count + 1;
    pthread_mutex_unlock(&count_mutex);
    return NULL;
}

void* set_count(void *args)
{
    long long c;
    pthread_mutex_lock(&count_mutex);
    c = count;
    pthread_mutex_unlock(&count_mutex);
    return NULL;
}

int main(void)
{
    pthread_t thread_increment;
    pthread_t thread_get;

    pthread_create(&thread_increment, NULL, increment_count, NULL);
    pthread_create(&thread_get, NULL, set_count, NULL);

    pthread_join(thread_get, NULL);
    pthread_join(thread_increment, NULL);
```

```
    return 1;
}
```

Check Information

Group: Concurrency
Language: C | C++
Default: On
Command-Line Syntax: `DATA_RACE`
Impact: High
CWE ID: 366, 413

See Also

`Data race including atomic operations` | `Data race through standard library function call` | `Deadlock` | `Destruction of locked mutex` | `Double lock` | `Double unlock` | `Missing lock` | `Missing unlock`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2014b

Data race including atomic operations

Multiple tasks perform unprotected operations on shared variable

Description

Data race including atomic operations occurs when:

1. Multiple tasks perform unprotected operations on a shared variable.
2. At least one task performs a write operation.

If you check for this defect, you can see data races on both atomic and non-atomic operations. To see data races on non-atomic operations alone, select `Data race`. Bug Finder considers an operation as atomic if it can be performed in one machine instruction. For instance, the operation:

```
int var = 0;
```

can be performed in one machine instruction on targets where the size of `int` is less than the word size on the target (or pointer size). See the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server. If you do not want to use this definition of atomic operations, turn on this checker.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**.

Risk

Data race can result in unpredictable values of the shared variable because you do not control the order of the operations in different tasks.

Fix

To fix this defect, protect the operations on the shared variable using critical sections, temporal exclusion or another means. See the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

To identify existing protections that you can reuse, see the table and graphs associated with the result. The table shows each pair of conflicting calls. The **Access Protections** column shows existing protections on the calls. To see the function call sequence leading to the conflicts, click the  icon. For an example, see below.

Examples

Unprotected Atomic Operation on Global Variable from Multiple Tasks

```
#include<stdio.h>

int var;

void begin_critical_section(void);
void end_critical_section(void);

void task1(void) {
    var = 1;
}

void task2(void) {
    int local_var;
    local_var = var;
    printf("%d", local_var);
}

void task3(void) {
    begin_critical_section();
    /* Operations in task3 */
    end_critical_section();
}
```

In this example, to emulate multitasking behavior, specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	task1 task2 task3	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section	end_critical_section

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
  -entry-points task1,task2,task3
  -critical-section-begin begin_critical_section:cs1
  -critical-section-end end_critical_section:cs1
```

In this example, the write operation `var=1;` in task `task1` executes concurrently with the read operation `local_var=var;` in task `task2`.

`task3` uses a critical section that can be reused for the other tasks.

Correction — Place Operations in Critical Section

One possible correction is to place these operations in the same critical section:

- `var=1;` in `task1`
- `local_var=var;` in `task2`

When `task1` enters its critical section, the other tasks cannot enter their critical sections until `task1` leaves its critical section. Therefore, the two operations cannot execute concurrently.

To implement the critical section, reuse the already existing critical section in `task3`. Place the two operations between calls to `begin_critical_section` and `end_critical_section`.

```
#include<stdio.h>

int var;

void begin_critical_section();
void end_critical_section();

void task1(void) {
    begin_critical_section();
    var = 1;
    end_critical_section();
}

void task2(void) {
    int local_var;
    begin_critical_section();
    local_var = var;
    end_critical_section();
    printf("%d", local_var);
}

void task3(void) {
    begin_critical_section();
    /* Operations in task3 */
    end_critical_section();
}
```

Correction — Make Tasks Temporally Exclusive

Another possible correction is to make the tasks `task1` and `task2` temporally exclusive. Temporally exclusive tasks cannot execute concurrently.

On the **Configuration** pane, specify the following additional options:

Option	Value
`Temporally exclusive tasks (-temporal-exclusions-file)`	`task1 task2`

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, use the following:

```
polyspace-bug-finder
    -temporal-exclusions-file "C:\exclusions_file.txt"
```

where the file `C:\exclusions_file.txt` has the following line:

```
task1 task2
```

Check Information

Group: Concurrency
Language: C | C++
Default: Off
Command-Line Syntax: `DATA_RACE_ALL`
Impact: Medium
CWE ID: 366, 413

See Also

`Data race` | `Data race through standard library function call` | `Deadlock` | `Destruction of locked mutex` | `Double lock` | `Double unlock` | `Missing lock` | `Missing unlock`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2014b

Data race through standard library function call

Multiple tasks make unprotected calls to thread-unsafe standard library function

Description

Data race through standard library function call occurs when:

1. Multiple tasks call the same standard library function.

   For instance, multiple tasks call the `strerror` function.
2. The calls are not protected using a common protection.

   For instance, the calls are not protected by the same critical section.

Functions flagged by this defect are not guaranteed to be reentrant. A function is reentrant if it can be interrupted and safely called again before its previous invocation completes execution. If a function is not reentrant, multiple tasks calling the function without protection can cause concurrency issues. For the list of functions that are flagged, see CON33-C: Avoid race conditions when using library functions.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**. For more information, see the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

The functions flagged by this defect are nonreentrant because their implementations can use global or static variables. When multiple tasks call the function without protection, the function call from one task can interfere with the call from another task. The two invocations of the function can concurrently access the global or static variables and cause unpredictable results.

The calls can also cause more serious security vulnerabilities, such as abnormal termination, denial-of-service attack, and data integrity violations.

Fix

To fix this defect, do one of the following:

- Use a reentrant version of the standard library function if it exists.

  For instance, instead of `strerror()`, use `strerror_r()` or `strerror_s()`. For alternatives to functions flagged by this defect, see the documentation for CON33-C.
- Protect the function calls using common critical sections or temporal exclusion.

  See `Critical section details (-critical-section-begin -critical-section-end)` and `Temporally exclusive tasks (-temporal-exclusions-file)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

  To identify existing protections that you can reuse, see the table and graphs associated with the result. The table shows each pair of conflicting calls. The **Access Protections** column shows existing protections on the calls. To see the function call sequence leading to the conflicts, click the  icon. For an example, see below.

Examples

Unprotected Call to Standard Library Function from Multiple Tasks

```
#include <errno.h>
#include <stdio.h>
#include <string.h>

void begin_critical_section(void);
void end_critical_section(void);

FILE *getFilePointer(void);

void func(FILE *fp) {
  fpos_t pos;
  errno = 0;
  if (0 != fgetpos(fp, &pos)) {
```

```
    char *errmsg = strerror(errno);
    printf("Could not get the file position: %s\n", errmsg);
  }
}

void task1(void) {
    FILE* fptr1 = getFilePointer();
    func(fptr1);
}

void task2(void) {
     FILE* fptr2 = getFilePointer();
     func(fptr2);
}

void task3(void) {
     FILE* fptr3 = getFilePointer();
     begin_critical_section();
     func(fptr3);
     end_critical_section();
}
```

In this example, to emulate multitasking behavior, specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	task1 task2 task3	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section	end_critical_section

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
  -entry-points task1,task2,task3
  -critical-section-begin begin_critical_section:cs1
  -critical-section-end end_critical_section:cs1
```

In this example, the tasks, `task1`, `task2` and `task3`, call the function `func`. `func` calls the nonreentrant standard library function, `strerror`.

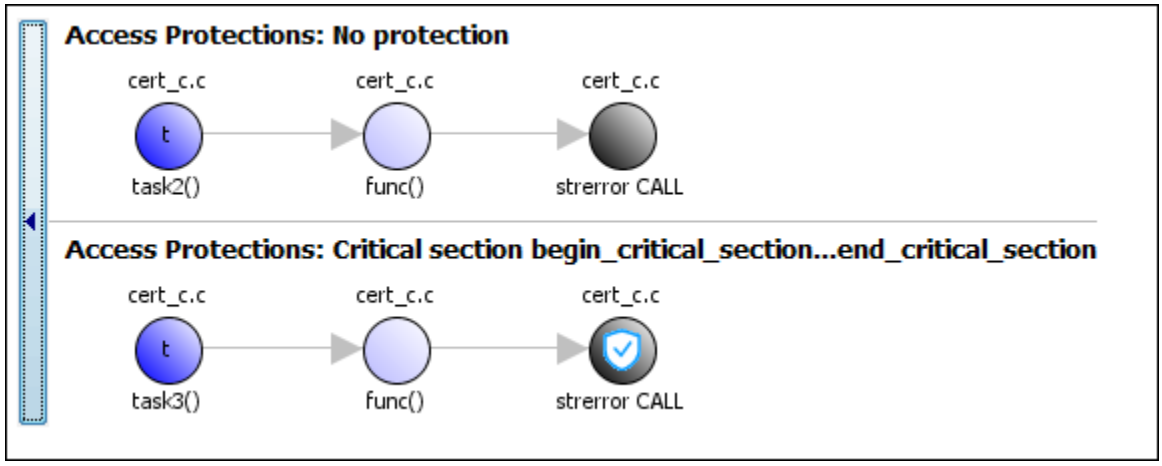
Though `task3` calls `func` inside a critical section, other tasks do not use the same critical section. Operations in the critical section of `task3` are not mutually exclusive with operations in other tasks.

These three tasks are calling a nonreentrant standard library function without common protection. In your result details, you see each pair of conflicting function calls.

! Data race through standard library function call (Impact: High)
Certain calls to function 'strerror' can interfere with each other and cause unpredictable results.
To avoid interference, calls to 'strerror' must be in the same critical section.

	Access	Access Protections	Task	File	Scope	Line
	Function call (Non atomic) Operation involves function call	No protection	task1()	data_race_std_lib.c	func()	14
	Function call (Non atomic) Operation involves function call	No protection	task2()	data_race_std_lib.c	func()	14
	Function call (Non atomic) Operation involves function call	No protection	task2()	data_race_std_lib.c	func()	14
	Function call (Non atomic) Operation involves function call	**Critical section begin_critical_section...end_critical_section**	task3()	data_race_std_lib.c	func()	14
	Function call (Non atomic) Operation involves function call	No protection	task1()	data_race_std_lib.c	func()	14
	Function call (Non atomic) Operation involves function call	**Critical section begin_critical_section...end_critical_section**	task3()	data_race_std_lib.c	func()	14

If you click the  icon, you see the function call sequence starting from the entry point to the standard library function call. You also see that the call starting from `task3` is in a critical section. The **Access Protections** entry shows the lock and unlock function that begin and end the critical section. In this example, you see the functions `begin_critical_section` and `end_critical_section`.



Correction — Use Reentrant Version of Standard Library Function

One possible correction is to use a reentrant version of the standard library function `strerror`. You can use the POSIX® version `strerror_r` which has the same functionality but also guarantees thread-safety.

```
#include <errno.h>
#include <stdio.h>
#include <string.h>

void begin_critical_section(void);
void end_critical_section(void);

FILE *getFilePointer(void);
enum { BUFFERSIZE = 64 };

void func(FILE *fp) {
  fpos_t pos;
  errno = 0;
  if (0 != fgetpos(fp, &pos)) {
    char errmsg[BUFFERSIZE];
    if (strerror_r(errno, errmsg, BUFFERSIZE) != 0) {
      /* Handle error */
    }
    printf("Could not get the file position: %s\n", errmsg);
  }
```

```
}

void task1(void) {
    FILE* fptr1 = getFilePointer();
    func(fptr1);
}

void task2(void) {
     FILE* fptr2 = getFilePointer();
     func(fptr2);
}

void task3(void) {
     FILE* fptr3 = getFilePointer();
     begin_critical_section();
     func(fptr3);
     end_critical_section();
}
```

Correction — Place Function Call in Critical Section

One possible correction is to place the call to `strerror` in critical section. You can implement the critical section in multiple ways.

For instance, you can place the call to the intermediate function `func` in the same critical section in the three tasks. When `task1` enters its critical section, the other tasks cannot enter their critical sections until `task1` leaves its critical section. The calls to `func` and therefore the calls to `strerror` from the three tasks cannot interfere with each other.

To implement the critical section, in each of the three tasks, call `func` between calls to `begin_critical_section` and `end_critical_section`.

```
#include <errno.h>
#include <stdio.h>
#include <string.h>

void begin_critical_section(void);
void end_critical_section(void);

FILE *getFilePointer(void);

void func(FILE *fp) {
  fpos_t pos;
```

```
  errno = 0;
  if (0 != fgetpos(fp, &pos)) {
    char *errmsg = strerror(errno);
    printf("Could not get the file position: %s\n", errmsg);
  }
}

void task1(void) {
    FILE* fptr1 = getFilePointer();
    begin_critical_section();
    func(fptr1);
    end_critical_section();
}

void task2(void) {
     FILE* fptr2 = getFilePointer();
     begin_critical_section();
     func(fptr2);
     end_critical_section();
}

void task3(void) {
     FILE* fptr3 = getFilePointer();
     begin_critical_section();
     func(fptr3);
     end_critical_section();
}
```

Correction — Make Tasks Temporally Exclusive

Another possible correction is to make the tasks, `task1`, `task2` and `task3`, temporally exclusive. Temporally exclusive tasks cannot execute concurrently.

On the **Configuration** pane, specify the following additional options:

Option	Value
`Temporally exclusive tasks (-temporal-exclusions-file)`	`task1 task2 task3`

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
    -temporal-exclusions-file "C:\exclusions_file.txt"
```

where the file `C:\exclusions_file.txt` has the following line:

```
task1 task2 task3
```

Result Information

Group: Concurrency
Language: C | C++
Default: On
Command-Line Syntax: `DATA_RACE_STD_LIB`
Impact: High
CWE ID: 366, 413

See Also

`Data race` | `Data race including atomic operations` | `Destruction of locked mutex` | `Double lock` | `Double unlock` | `Missing lock` | `Missing unlock`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2016b

Code deactivated by constant false condition

Code segment deactivated by `#if 0` directive or `if(0)` condition

Description

Code deactivated by constant false condition occurs when a block of code is deactivated using a `#if 0` directive or `if(0)` condition.

Risk

A `#if 0` directive or `if(0)` condition is used to temporarily deactivate segments of code. If your production code contains these directives, it means that the deactivation has not been lifted before shipping the code.

Fix

If the segment of code is present for debugging purposes only, remove the segment from production code. If the deactivation occurred by accident, remove the `#if 0` and `#endif` statements.

Often, a segment of code is deactivated for specific conditions, for instance, a specific operating system. Use macros with the `#if` directive to indicate these conditions instead of deactivating the code completely with a `#if 0` directive. For instance, GCC provides macros to detect the Windows operating system:

```
#ifdef _WIN32
   //Code deactivated for all operating systems
   //Other than 32-bit Windows
#endif
```

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Code Deactivated by Constant False Condition Error

```
#include<stdio.h>
int Trim_Value(int* Arr,int Size,int Cutoff)
{
    int Count=0;

    for(int i=0;i < Size;i++){
        if(Arr[i]>Cutoff){
            Arr[i]=Cutoff;
            Count++;
        }
    }

    #if 0
    /* Defect: Code Segment Deactivated */

    if(Count==0){
        printf("Values less than cutoff.");
    }
     #endif

    return Count;
}
```

In the preceding code, the `printf` statement is placed within a `#if #endif` directive. The software treats the portion within the directive as code comments and not compiled.

Correction — Change `#if 0` to `#if 1`

Unless you intended to deactivate the `printf` statement, one possible correction is to reactivate the block of code in the `#if #endif` directive. To reactivate the block, change `#if 0` to `#if 1`.

```
#include<stdio.h>
int Trim_Value(int* Arr,int Size,int Cutoff)
{
 int Count=0;

 for(int i=0;i < Size;i++)
     {
```

```
      if(Arr[i]>Cutoff)
            {
             Arr[i]=Cutoff;
             Count++;
            }
     }


 /* Fix: Replace #if 0 by #if 1 */
 #if 1
      if(Count==0)
           {
            printf("Values less than cutoff.");
           }
 #endif

 return Count;
}
```

Check Information

Group: Data flow
Language: C | C++
Default: off
Command-Line Syntax: `DEACTIVATED_CODE`
Impact: Low

See Also

`Dead code` | `Unreachable code` | `Useless if`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Dead code

Code does not execute

Description

Dead code occurs when a block of code cannot be reached because of a condition that is always true or false. This defect excludes:

- `Code deactivated by constant false condition`, which checks for directives with compile-time constants such as `#if 0` or `if(0)`.
- `Unreachable code`, which checks for code after a control escape such as `goto`, `break`, or `return`.
- `Useless if`, which checks for if statements that are always true.

Risk

Dead code wastes development time, memory and execution cycles. Developers have to maintain code that is not being executed. Instructions that are not executed still have to be stored and cached.

Dead code often represents legacy code that is no longer used. Cleaning up dead code periodically reduces future maintenance.

Fix

The fix depends on the root cause of the defect. For instance, the root cause can be an error condition that is checked twice on the same execution path, making the second check redundant and the corresponding block dead code.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If you see dead code from use of functions such as `isinf` and `isnan`, enable an analysis mode that takes into account non-finite values. See `Consider non finite floats (-allow-non-finite-floats)` For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server..

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Dead Code from `if`-Statement

```
#include <stdio.h>

int Return_From_Table(int ch){

    int table[5];

    /* Create a table */
    for(int i=0;i<=4;i++){
        table[i]=i^2+i+1;
    }

    if(table[ch]>100){ /* Defect: Condition always false */
         return 0;
    }
    return table[ch];
}
```

The maximum value in the array `table` is `4^2+4+1=21`, so the test expression `table[ch]>100` always evaluates to false. The `return 0` in the `if` statement is not executed.

Correction — Remove Dead Code

One possible correction is to remove the `if` condition from the code.

```
#include <stdio.h>

int Return_From_Table(int ch){
```

```
    int table[5];

    /* Create a table */
    for(int i=0;i<=4;i++){
        table[i]=i^2+i+1;
    }

    return table[ch];
}
```

Dead Code for `if` with Enumerated Type

```
typedef enum _suit {UNKNOWN_SUIT, SPADES, HEARTS, DIAMONDS, CLUBS} suit;
suit nextcard(void);
void do_something(suit s);

void bridge(void)
{
    suit card = nextcard();
    if ((card < SPADES) || (card > CLUBS))
        card = UNKNOWN_SUIT;

    if (card > 7) {
        do_something(card);
    }
}
```

The type `suit` is enumerated with five options. However, the conditional expression `card > 7` always evaluates to false because `card` can be at most 5. The content in the `if` statement is not executed.

Correction — Change Condition

One possible correction is to change the if-condition in the code. In this correction, the 7 is changed to HEART to relate directly to the type of `card`.

```
typedef enum _suit {UNKNOWN_SUIT, SPADES, HEARTS, DIAMONDS, CLUBS} suit;
suit nextcard(void);
void do_something(suit s);

void bridge(void)
{
    suit card = nextcard();
    if ((card < SPADES) || (card > CLUBS))
```

```
        card = UNKNOWN_SUIT;

    if (card > HEARTS) {
        do_something(card);
    }
}
```

Check Information

Group: Data flow
Language: C | C++
Default: On
Command-Line Syntax: `DEAD_CODE`
Impact: Low
CWE ID: 561

See Also

`Code deactivated by constant false condition` | `Unreachable code` | `Useless if`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Deadlock

Call sequence to lock functions cause two tasks to block each other

Description

Deadlock occurs when multiple tasks are stuck in their critical sections (CS) because:

- Each CS waits for another CS to end.
- The critical sections (CS) form a closed cycle. For example:
  - CS #1 waits for CS #2 to end, and CS #2 waits for CS #1 to end.
  - CS #1 waits for CS #2 to end, CS #2 waits for CS #3 to end and CS #3 waits for CS #1 to end.

Polyspace expects critical sections of code to follow a specific format. A critical section lies between a call to a lock function and a call to an unlock function. When a task `my_task` calls a lock function `my_lock`, other tasks calling `my_lock` must wait until `my_task` calls the corresponding unlock function. Both lock and unlock functions must have the form `void func(void)`.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**.

Risk

Each task waits for a critical section in another task to end and is unable to proceed. The program can freeze indefinitely.

Fix

The fix depends on the root cause of the defect. You can try to break the cyclic order between the tasks in one of these ways:

- Write down all critical sections involved in the deadlock in a certain sequence. Whenever you call the lock functions of the critical sections within a task, respect the order in that sequence. See an example below.

- If one of the critical sections involved in a deadlock occurs in an interrupt, try to disable all interrupts during critical sections in all tasks. See `Disabling all interrupts (-routine-disable-interrupts -routine-enable-interrupts)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Reviewing this defect is an opportunity to check if all operations in your critical section are really meant to be executed as an atomic block. It is a good practice to keep critical sections at a bare minimum.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Deadlock with Two Tasks

```
void task1(void);
void task2(void);

int var;
void perform_task_cycle(void) {
 var++;
}

void begin_critical_section_1(void);
void end_critical_section_1(void);

void begin_critical_section_2(void);
void end_critical_section_2(void);

void task1() {
 while(1) {
    begin_critical_section_1();
    begin_critical_section_2();
    perform_task_cycle();
    end_critical_section_2();
    end_critical_section_1();
```

```
 }
}

void task2() {
 while(1) {
    begin_critical_section_2();
    begin_critical_section_1();
    perform_task_cycle();
    end_critical_section_1();
    end_critical_section_2();
 }
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	task1 task2	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section_1	end_critical_section_1
	begin_critical_section_2	end_critical_section_2

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

A **Deadlock** occurs because the instructions can execute in the following sequence:

1. `task1` calls `begin_critical_section_1`.
2. `task2` calls `begin_critical_section_2`.
3. `task1` reaches the instruction `begin_critical_section_2();`. Since `task2` has already called `begin_critical_section_2`, `task1` waits for `task2` to call `end_critical_section_2`.

4. `task2` reaches the instruction `begin_critical_section_1();`. Since `task1` has already called `begin_critical_section_1`, `task2` waits for `task1` to call `end_critical_section_1`.

Correction-Follow Same Locking Sequence in Both Tasks

One possible correction is to follow the same sequence of calls to lock and unlock functions in both `task1` and `task2`.

```
void task1(void);
void task2(void);
void perform_task_cycle(void);

void begin_critical_section_1(void);
void end_critical_section_1(void);

void begin_critical_section_2(void);
void end_critical_section_2(void);

void task1() {
 while(1) {
    begin_critical_section_1();
    begin_critical_section_2();
    perform_task_cycle();
    end_critical_section_2();
    end_critical_section_1();
 }
}

void task2() {
 while(1) {
    begin_critical_section_1();
    begin_critical_section_2();
    perform_task_cycle();
    end_critical_section_2();
    end_critical_section_1();
 }
}
```

Deadlock with More Than Two Tasks

```
int var;
void performTaskCycle() {
 var++;
}

void lock1(void);
void lock2(void);
void lock3(void);


void unlock1(void);
void unlock2(void);
void unlock3(void);

void task1() {
 while(1) {
    lock1();
    lock2();
    performTaskCycle();
    unlock2();
    unlock1();
 }
}

void task2() {
 while(1) {
    lock2();
    lock3();
    performTaskCycle();
    unlock3();
    unlock2();
 }
}

void task3() {
 while(1) {
    lock3();
    lock1();
    performTaskCycle();
```

```
    unlock1();
    unlock3();
 }
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	Specification	
Configure multitasking manually	☑	

Entry points	`task1`
	`task2`
	`task3`	

Critical section details	**Starting routine**	**Ending routine**
	`lock1`	`unlock1`
	`lock2`	`unlock2`
	`lock3`	`unlock3`

A **Deadlock** occurs because the instructions can execute in the following sequence:

1. `task1` calls `lock1`.
2. `task2` calls `lock2`.
3. `task3` calls `lock3`.
4. `task1` reaches the instruction `lock2();`. Since `task2` has already called `lock2`, `task1` waits for call to `unlock2`.
5. `task2` reaches the instruction `lock3();`. Since `task3` has already called `lock3`, `task2` waits for call to `unlock3`.
6. `task3` reaches the instruction `lock1();`. Since `task1` has already called `lock1`, `task3` waits for call to `unlock1`.

Correction — Break Cyclic Order

To break the cyclic order between critical sections, note every lock function in your code in a certain sequence, for example:

1. `lock1`

2. `lock2`
3. `lock3`

If you use more than one lock function in a task, use them in the order in which they appear in the sequence. For example, you can use `lock1` followed by `lock2` but not `lock2` followed by `lock1`.

```
int var;
void performTaskCycle() {
 var++;
}

void lock1(void);
void lock2(void);
void lock3(void);

void unlock1(void);
void unlock2(void);
void unlock3(void);

void task1() {
 while(1) {
    lock1();
    lock2();
    performTaskCycle();
    unlock2();
    unlock1();
 }
}

void task2() {
 while(1) {
    lock2();
    lock3();
    performTaskCycle();
    unlock3();
    unlock2();
 }
}

void task3() {
```

```
 while(1) {
    lock1();
    lock3();
    performTaskCycle();
    unlock3();
    unlock1();
 }
}
```

Check Information

Group: Concurrency
Language: C | C++
Default: On
Command-Line Syntax: DEADLOCK
Impact: High
CWE ID: 833

See Also

`Data race` | `Data race including atomic operations` | `Data race through standard library function call` | `Destruction of locked mutex` | `Double lock` | `Double unlock` | `Missing lock` | `Missing unlock`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2014b

Declaration mismatch

Mismatch between function or variable declarations

Description

Declaration mismatch occurs when a function or variable declaration does not match other instances of the function or variable.

Risk

When a mismatch occurs between two variable declarations in different compilation units, a typical linker follows an algorithm to pick one declaration for the variable. If you expect a variable declaration that is different from the one chosen by the linker, you can see unexpected results when the variable is used.

A similar issue can occur with mismatch in function declarations.

Fix

The fix depends on the type of declaration mismatch. If both declarations indeed refer to the same object, use the same declaration. If the declarations refer to different objects, change the names of the one of the variables. If you change a variable name, remember to make the change in all places that use the variable.

Sometimes, declaration mismatches can occur because the declarations are affected by previous preprocessing directives. For instance, a declaration occurs in a macro, and the macro is defined on one inclusion path but undefined in another. These declaration mismatches can be tricky to debug. Identify the divergence between the two inclusion paths and fix the conflicting macro definitions.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Inconsistent Declarations in Two Files

file1.c

```
int foo(void) {
    return 1;
}
```

file2.c

```
double foo(void);

int bar(void) {
    return (int)foo();
}
```

In this example, *file1.c* declares `foo()` as returning an integer. In *file2.c*, `foo()` is declared as returning a double. This difference raises a defect on the second instance of `foo` in *file2*.

Correction — Align the Function Return Values

One possible correction is to change the function declarations so that they match. In this example, by changing the declaration of `foo` in *file2.c* to match *file1.c*, the defect is fixed.

file1.c

```
int foo(void) {
    return 1;
}
```

file2.c

```
int foo(void);

int bar(void) {
    return foo();
}
```

Inconsistent Structure Alignment

test1.c

```
#include "square.h"
#include "circle.h"
struct aCircle circle;
struct aSquare square;

int main(){
    square.side=1;
    circle.radius=1;
    return 0;
}
```

test2.c

```
#include "circle.h"
#include "square.h"
struct aCircle circle;
struct aSquare square;

int main(){
    square.side=1;
    circle.radius=1;
    return 0;
}
```

circle.h

```
#pragma pack(1)

extern struct aCircle{
    int radius;
} circle;
```

square.h

```
extern struct aSquare {
    unsigned int side:1;
} square;
```

In this example, a declaration mismatch defect is raised on `square` in *square.h* because Polyspace infers that `square` in *square.h* does not have the same alignment as `square` in *test2.c*. This error occurs because the `#pragma pack(1)` statement in *circle.h* declares specific alignment. In *test2.c*, *circle.h* is included before *square.h*. Therefore, the `#pragma pack(1)` statement from *circle.h* is not reset to the default alignment after the `aCircle` structure. Because of this omission, *test2.c* infers that the `aSquare square` structure also has an alignment of `1` byte.

Correction — Close Packing Statements

One possible correction is to reset the structure alignment after the `aCircle` struct declaration. For the GNU or Microsoft® Visual compilers, fix the defect by adding a `#pragma pack()` statement at the end of *circle.h*.

test1.c	*test2.c*

`#include "square.h"`
`#include "circle.h"`
`struct aCircle circle;`
`struct aSquare square;`
 	
`int main(){`
`  square.side=1;`
`  circle.radius=1;`
`  return 0;`
`}`
	`#include "circle.h"`
	`#include "square.h"`
	`struct aCircle circle;`
	`struct aSquare square;`
	
	`int main(){`
	`  square.side=1;`
	`  circle.radius=1;`
	`  return 0;`
	`}`

circle.h
 	
`#pragma pack(1)`
 	
`extern struct aCircle{`
`  int radius;`
`} circle;`
 	
`#pragma pack()`
	square.h
	
	`extern struct aSquare {`
	`  unsigned int side:1;`
	`} square;`

Other compilers require different `#pragma pack` syntax. For your syntax, see the documentation for your compiler.

Correction — Use the `Ignore pragma pack directives` Option

One possible correction is to add the `Ignore pragma pack directives` option to your Bug Finder analysis. If you want the structure alignment to change for each structure, and you do not want to see this **Declaration mismatch** defect, use this correction.

1. On the Configuration pane, select the **Advanced Settings** pane.
2. In the **Other** box, enter `-ignore-pragma-pack`.
3. Rerun your analysis.

   The **Declaration mismatch** defect is resolved.

Check Information

Group: Programming
Language: C | C++

Default: On
Command-Line Syntax: `DECL_MISMATCH`
Impact: High
CWE ID: 685, 686

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Delete of void pointer

`delete` operates on a `void*` pointer pointing to an object

Description

Delete of void pointer occurs when the `delete` operator operates on a `void*` pointer.

Risk

Deleting a `void*` pointer is undefined according to the C++ Standard.

If the object is of type `MyClass` and the `delete` operator operates on a `void*` pointer pointing to the object, the `MyClass` destructor is not called.

If the destructor contains cleanup operations such as release of resources or decreasing a counter value, the operations do not take place.

Fix

Cast the `void*` pointer to the appropriate type. Perform the `delete` operation on the result of the cast.

For instance, if the `void*` pointer points to a `MyClass` object, cast the pointer to `MyClass*`.

Examples

Delete of `void*` Pointer

```
#include <iostream>

class MyClass {
public:
    explicit MyClass(int i):m_i(i) {}
    ~MyClass() {
```

```
        std::cout << "Delete MyClass(" << m_i << ")" << std::endl;
    }
private:
    int m_i;
};

void my_delete(void* ptr) {
    delete ptr;
}


int main() {
    MyClass* pt = new MyClass(0);
    my_delete(pt);
    return 0;
}
```

In this example, the function `my_delete` is designed to perform the `delete` operation on any type. However, in the function body, the `delete` operation acts on a `void*` pointer, `ptr`. Therefore, when you call `my_delete` with an argument of type `MyClass`, the `MyClass` destructor is not called.

Correction — Cast `void*` Pointer to `MyClass*`

One possible solution is to use a function template instead of a function for `my_delete`.

```
#include <iostream>

class MyClass {
public:
    explicit MyClass(int i):m_i(i) {}
    ~MyClass() {
        std::cout << "Delete MyClass(" << m_i << ")" << std::endl;
    }
private:
    int m_i;
};


template<typename T> void safe_delete(T*& ptr) {
    delete ptr;
    ptr = NULL;
}
```

```
int main() {
    MyClass* pt = new MyClass(0);
    safe_delete(pt);
    return 0;
}
```

Result Information

Group: Good practice
Language: C++
Default: Off
Command-Line Syntax: DELETE_OF_VOID_PTR
Impact: Low

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Destruction of locked mutex

Task tries to destroy a mutex in the locked state

Description

Destruction of locked mutex occurs when a task destroys a mutex after it is locked (and before it is unlocked). The locking and destruction can happen in the same task or different tasks.

Risk

A mutex is locked to protect shared variables from concurrent access. If a mutex is destroyed in the locked state, the protection does not apply.

Fix

To fix this defect, destroy the mutex only after you unlock it. It is a good design practice to:

- Initialize a mutex *before* creating the threads where you use the mutex.
- Destroy a mutex *after* joining the threads that you created.

On the **Result Details** pane, you see two events, the locking and destruction of the mutex, and the tasks that initiated the events. To navigate to the corresponding line in your source code, click the event.

Examples

Locking and Destruction in Different Tasks

```
#include <pthread.h>
```

```
pthread_mutex_t lock1;
pthread_mutex_t lock2;
pthread_mutex_t lock3;

void t0 (void) {
  pthread_mutex_lock (&lock1);
  pthread_mutex_lock (&lock2);
  pthread_mutex_lock (&lock3);
  pthread_mutex_unlock (&lock2);
  pthread_mutex_unlock (&lock1);
  pthread_mutex_unlock (&lock3);
}

void t1 (void) {
  pthread_mutex_lock (&lock1);
  pthread_mutex_lock (&lock2);
  pthread_mutex_destroy (&lock3);
  pthread_mutex_unlock (&lock2);
  pthread_mutex_unlock (&lock1);
}
```

In this example, after task `t0` locks the mutex `lock3`, task `t1` can destroy it. The destruction occurs if the following events happen in sequence:

1. `t0` acquires `lock3`.
2. `t0` releases `lock2`.
3. `t0` releases `lock1`.
4. `t1` acquires the lock `lock1` released by `t0`.
5. `t1` acquires the lock `lock2` released by `t0`.
6. `t1` destroys `lock3`.

For simplicity, this example uses a mix of automatic and manual concurrency detection. The tasks `t0` and `t1` are manually specified as entry points by using the option `Tasks (-entry-points)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.The critical sections are implemented through primitives `pthread_mutex_lock` and `pthread_mutex_unlock` that the software detects automatically. In practice, for entry point specification (thread creation), you will use primitives such as `pthread_create`. The next example shows how the defect can appear when you use `pthread_create`.

Correction — Place Lock-Unlock Pair Together in Same Critical Section as Destruction

The locking and destruction of `lock3` occurs inside the critical section imposed by `lock1` and `lock2`, but the unlocking occurs outside. One possible correction is to place the lock-unlock pair in the same critical section as the destruction of the mutex. Use one of these critical sections:

- Critical section imposed by `lock1` alone.
- Critical section imposed by `lock1` and `lock2`.

In this corrected code, the lock-unlock pair and the destruction is placed in the critical section imposed by `lock1` and `lock2`. When `t0` acquires `lock1` and `lock2`, `t1` has to wait for their release before it executes the instruction `pthread_mutex_destroy (&lock3);`. Therefore, `t1` cannot destroy mutex `lock3` in the locked state.

```
#include <pthread.h>

pthread_mutex_t lock1;
pthread_mutex_t lock2;
pthread_mutex_t lock3;

void t0 (void) {
  pthread_mutex_lock (&lock1);
  pthread_mutex_lock (&lock2);

  pthread_mutex_lock (&lock3);
  pthread_mutex_unlock (&lock3);

  pthread_mutex_unlock (&lock2);
  pthread_mutex_unlock (&lock1);
}

void t1 (void) {
  pthread_mutex_lock (&lock1);
  pthread_mutex_lock (&lock2);

  pthread_mutex_destroy (&lock3);

  pthread_mutex_unlock (&lock2);
  pthread_mutex_unlock (&lock1);
```

```
}
```

Locking and Destruction in Start Routine of Thread

```
#include <pthread.h>

/* Define globally accessible variables and a mutex */
#define NUMTHREADS 4
pthread_t callThd[NUMTHREADS];
pthread_mutex_t lock;
void atomic_operation(void);

void *do_create(void *arg) {
    /* Creation thread */
    pthread_mutex_init(&lock, NULL);
    pthread_exit((void*) 0);
}

void *do_work(void *arg) {
    /* Worker thread */
    pthread_mutex_lock (&lock);
    atomic_operation();
    pthread_mutex_unlock (&lock);
    pthread_exit((void*) 0);
}

void *do_destroy(void *arg) {
    /* Destruction thread */
    pthread_mutex_destroy(&lock);
    pthread_exit((void*) 0);
}

int main (int argc, char *argv[]) {
   int i;
   void *status;
   pthread_attr_t attr;


   /* Create threads */
   pthread_attr_init(&attr);
   pthread_attr_setdetachstate(&attr, PTHREAD_CREATE_JOINABLE);

   /* Thread that initializes mutex */
```

```
   pthread_create(&callThd[0], &attr, do_create, NULL);

   /* Threads that use mutex for atomic operation*/
   for(i=0; i<NUMTHREADS-1; i++) {
      pthread_create(&callThd[i], &attr, do_work, (void *)i);
   }

   /* Thread that destroys mutex */
   pthread_create(&callThd[NUMTHREADS -1], &attr, do_destroy, NULL);

   pthread_attr_destroy(&attr);

   /* Join threads */
   for(i=0; i<NUMTHREADS; i++) {
      pthread_join(callThd[i], &status);
   }

   pthread_exit(NULL);
}
```

In this example, four threads are created. The threads are assigned different actions.

- The first thread `callThd[0]` initializes the mutex `lock`.
- The second and third threads, `callThd[1]` and `callThd[2]`, perform an atomic operation protected by the mutex `lock`.
- The fourth thread `callThd[3]` destroys the mutex `lock`.

The threads can interrupt each other. Therefore, immediately after the second or third thread locks the mutex, the fourth thread can destroy it.

Correction — Initialize and Destroy Mutex Outside Start Routine

One possible correction is to initialize and destroy the mutex in the `main` function outside the start routine of the threads. The threads perform only the atomic operation. You need two fewer threads because the mutex initialization and destruction threads are not required.

```
#include <pthread.h>

/* Define globally accessible variables and a mutex */
#define NUMTHREADS 2
pthread_t callThd[NUMTHREADS];
pthread_mutex_t lock;
```

```
void atomic_operation(void);

void *do_work(void *arg) {
   pthread_mutex_lock (&lock);
   atomic_operation();
   pthread_mutex_unlock (&lock);
   pthread_exit((void*) 0);
}

int main (int argc, char *argv[]) {
   int i;
   void *status;
   pthread_attr_t attr;


   /* Create threads */
   pthread_attr_init(&attr);
   pthread_attr_setdetachstate(&attr, PTHREAD_CREATE_JOINABLE);

   /* Initialize mutex */
   pthread_mutex_init(&lock, NULL);

   for(i=0; i<NUMTHREADS; i++) {
      pthread_create(&callThd[i], &attr, do_work, (void *)i);
   }

   pthread_attr_destroy(&attr);

   /* Join threads */
   for(i=0; i<NUMTHREADS; i++) {
      pthread_join(callThd[i], &status);
   }

   /* Destroy mutex */
   pthread_mutex_destroy(&lock);

   pthread_exit(NULL);
}
```

Correction — Use A Second Mutex To Protect Lock-Unlock Pair and Destruction

Another possible correction is to use a second mutex and protect the lock-unlock pair from the destruction. This corrected code uses the mutex `lock2` to achieve this

protection. The second mutex is initialized in the `main` function outside the start routine of the threads.

```
#include <pthread.h>

/* Define globally accessible variables and a mutex */
#define NUMTHREADS 4
pthread_t callThd[NUMTHREADS];
pthread_mutex_t lock;
pthread_mutex_t lock2;
void atomic_operation(void);

void *do_create(void *arg) {
    /* Creation thread */
    pthread_mutex_init(&lock, NULL);
    pthread_exit((void*) 0);
}

void *do_work(void *arg) {
    /* Worker thread */
    pthread_mutex_lock (&lock2);
    pthread_mutex_lock (&lock);
    atomic_operation();
    pthread_mutex_unlock (&lock);
    pthread_mutex_unlock (&lock2);
    pthread_exit((void*) 0);
}

void *do_destroy(void *arg) {
    /* Destruction thread */
    pthread_mutex_lock (&lock2);
    pthread_mutex_destroy(&lock);
    pthread_mutex_unlock (&lock2);
    pthread_exit((void*) 0);
}


int main (int argc, char *argv[]) {
   int i;
   void *status;
   pthread_attr_t attr;


   /* Create threads */
```

```
   pthread_attr_init(&attr);
   pthread_attr_setdetachstate(&attr, PTHREAD_CREATE_JOINABLE);

   /* Initialize second mutex */
   pthread_mutex_init(&lock2, NULL);

   /* Thread that initializes first mutex */
   pthread_create(&callThd[0], &attr, do_create, NULL);

   /* Threads that use first mutex for atomic operation */
   /* The threads use second mutex to protect first from destruction in locked state*/
   for(i=0; i<NUMTHREADS-1; i++) {
      pthread_create(&callThd[i], &attr, do_work, (void *)i);
   }

   /* Thread that destroys first mutex */
   /* The thread uses the second mutex to prevent destruction of locked mutex */
   pthread_create(&callThd[NUMTHREADS -1], &attr, do_destroy, NULL);


   pthread_attr_destroy(&attr);

   /* Join threads */
   for(i=0; i<NUMTHREADS; i++) {
      pthread_join(callThd[i], &status);
   }

   /* Destroy second mutex */
   pthread_mutex_destroy(&lock2);

   pthread_exit(NULL);
}
```

Result Information

Group: Concurrency
Language: C | C++
Default: Off
Command-Line Syntax: DESTROY_LOCKED
Impact: Medium
CWE ID: 667, 826

See Also

`Data race` | `Data race including atomic operations` | `Data race through standard library function call` | `Deadlock` | `Double lock` | `Double unlock` | `Missing lock` | `Missing unlock`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2016b

Deallocation of previously deallocated pointer

Memory freed more than once without allocation

Description

Deallocation of previously deallocated pointer occurs when a block of memory is freed more than once using the `free` function without an intermediate allocation.

Risk

When a pointer is allocated dynamic memory with `malloc`, `calloc` or `realloc`, it points to a memory location on the heap. When you use the `free` function on this pointer, the associated block of memory is freed for reallocation. Trying to free this block of memory can result in a segmentation fault.

Fix

The fix depends on the root cause of the defect. See if you intended to allocate a memory block to the pointer between the first deallocation and the second. Otherwise, remove the second `free` statement.

As a good practice, after you free a memory block, assign the corresponding pointer to NULL. Before freeing pointers, check them for NULL values and handle the error. In this way, you are protected against freeing an already freed block.

Examples

Deallocation of Previously Deallocated Pointer Error

```
#include <stdlib.h>

void allocate_and_free(void)
```

```
{

    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return;

    *pi = 2;
    free(pi);
    free (pi);
    /* Defect: pi has already been freed */
}
```

The first `free` statement releases the block of memory that `pi` refers to. The second `free` statement on `pi` releases a block of memory that has been freed already.

Correction — Remove Duplicate Deallocation

One possible correction is to remove the second `free` statement.

```
#include <stdlib.h>

void allocate_and_free(void)
{

    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return;

    *pi = 2;
    free(pi);
    /* Fix: remove second deallocation */
 }
```

Check Information

Group: Dynamic memory
Language: C | C++
Default: On
Command-Line Syntax: `DOUBLE_DEALLOCATION`
Impact: High
CWE ID: 415, 825

See Also

`Use of previously freed pointer`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Double lock

Lock function is called twice in a task without an intermediate call to unlock function

Description

Double lock occurs when:

- A task calls a lock function `my_lock`.
- The task calls `my_lock` again before calling the corresponding unlock function.

In multitasking code, a lock function begins a critical section of code and an unlock function ends it. When a task `task1` calls a lock function `lock`, other tasks calling `lock` must wait until `task` calls the corresponding unlock function. Polyspace requires that both lock and unlock functions must have the form `void func(void)`.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**.

Risk

A call to a lock function begins a critical section so that other tasks have to wait to enter the same critical section. If the same lock function is called again within the critical section, the task blocks itself.

Fix

The fix depends on the root cause of the defect. A double lock defect often indicates a coding error. Perhaps you omitted the call to an unlock function to end a previous critical section and started the next critical section. Perhaps you wanted to use a different lock function for the second critical section.

Identify each critical section of code, that is, the section that you want to be executed as an atomic block. Call a lock function at the beginning of the section. Within the critical section, make sure that you do not call the lock function again. At the end of the section, call the unlock function that corresponds to the lock function.

See examples of fixes below. To avoid the issue, you can follow the practice of calling the lock and unlock functions in the same module at the same level of abstraction. For instance, in this example, `func` calls the lock and unlock function at the same level but `func2` does not.

```
void func() {
  my_lock();
  {
    ...
  }
  my_unlock();
}

void func2() {
  {
   my_lock();
   ...
  }
  my_unlock();
}
```

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Double Lock

```
int global_var;

void lock(void);
void unlock(void);

void task1(void)
{
    lock();
    global_var += 1;
    lock();
    global_var += 1;
```

```
    unlock();
}

void task2(void)
{
    lock();
    global_var += 1;
    unlock();
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	Value	
Configure multitasking manually	☑	
Tasks (-entry-points)	task1 task2	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	lock	unlock

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
  -entry-points task1,task2
  -critical-section-begin lock:cs1
  -critical-section-end unlock:cs1
```

`task1` enters a critical section through the call `lock();`. `task1` calls `lock` again before it leaves the critical section through the call `unlock();`.

Correction — Remove First Lock

If you want the first `global_var+=1;` to be outside the critical section, one possible correction is to remove the first call to `lock`. However, if other tasks are using `global_var`, this code can produce a `Data race` error.

```
int global_var;

void lock(void);
void unlock(void);

void task1(void)
{
    global_var += 1;
    lock();
    global_var += 1;
    unlock();
}

void task2(void)
{
    lock();
    global_var += 1;
    unlock();
}
```

Correction — Remove Second Lock

If you want the first `global_var+=1;` to be inside the critical section, one possible correction is to remove the second call to `lock`.

```
int global_var;

void lock(void);
void unlock(void);

void task1(void)
{
    lock();
    global_var += 1;
    global_var += 1;
    unlock();
}

void task2(void)
```

```
{
    lock();
    global_var += 1;
    unlock();
}
```

Correction — Add Another Unlock

If you want the second `global_var+=1;` to be inside a critical section, another possible correction is to add another call to `unlock`.

```
int global_var;

void lock(void);
void unlock(void);

void task1(void)
{
    lock();
    global_var += 1;
    unlock();
    lock();
    global_var += 1;
    unlock();
}

void task2(void)
{
    lock();
    global_var += 1;
    unlock();
}
```

Double Lock with Function Call

```
int global_var;

void lock(void);
```

```
void unlock(void);

void performOperation(void) {
  lock();
  global_var++;
}

void task1(void)
{
    lock();
    global_var += 1;
    performOperation();
    unlock();
}

void task2(void)
{
    lock();
    global_var += 1;
    unlock();
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	task1 task2	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	lock	unlock

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

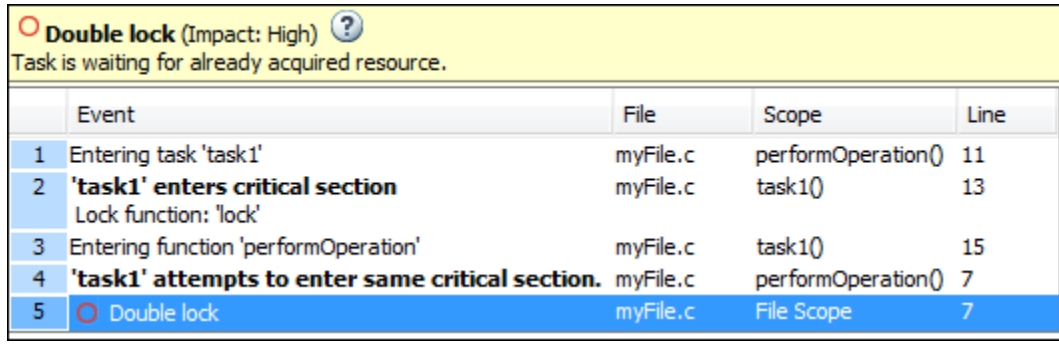
```
polyspace-bug-finder
  -entry-points task1,task2
```

```
-critical-section-begin lock:cs1
-critical-section-end unlock:cs1
```

`task1` enters a critical section through the call `lock();`. `task1` calls the function `performOperation`. In `performOperation`, `lock` is called again even though `task1` has not left the critical section through the call `unlock();`.

In the result details for the defect, you see the sequence of instructions leading to the defect. For instance, you see that following the first entry into the critical section, the execution path:

- Enters function `performOperation`.
- Inside `performOperation`, attempts to enter the same critical section once again.



You can click each event to navigate to the corresponding line in the source code.

Correction — Remove Second Lock

One possible correction is to remove the call to `lock` in `task1`.

```
int global_var;

void lock(void);
void unlock(void);

void performOperation(void) {
  global_var++;
}
```

```
void task1(void)
{
    lock();
    global_var += 1;
    performOperation();
    unlock();
}

void task2(void)
{
    lock();
    global_var += 1;
    unlock();
}
```

Check Information

Group: Concurrency
Language: C | C++
Default: On
Command-Line Syntax: DOUBLE_LOCK
Impact: High
CWE ID: 764

See Also

`Data race` | `Data race including atomic operations` | `Data race through standard library function call` | `Deadlock` | `Destruction of locked mutex` | `Double unlock` | `Missing lock` | `Missing unlock`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2014b

Closing a previously closed resource

Function closes a previously closed stream

Description

Closing a previously closed resource occurs when a function attempts to close a stream that was closed earlier in your code and not reopened later.

Risk

The standard states that the value of a `FILE*` pointer is indeterminate after you close the stream associated with it. Performing the close operation on the `FILE*` pointer again can cause unwanted behavior.

Fix

Remove the redundant close operation.

Examples

Closing Previously Closed Resource

```
#include <stdio.h>

void func(char* data) {
    FILE* fp = fopen("file.txt", "w");
    if(fp!=NULL) {
        if(data)
            fputc(*data,fp);
        else
            fclose(fp);
    }
    fclose(fp);
}
```

In this example, if `fp` is not `NULL` and `data` is `NULL`, the `fclose` operation occurs on `fp` twice in succession.

Correction — Remove Close Operation

One possible correction is to remove the last `fclose` operation. To avoid a resource leak, you must also place an `fclose` operation in the `if(data)` block.

```
#include <stdio.h>

void func(char* data) {
    FILE* fp = fopen("file.txt", "w");
    if(fp!=NULL) {
        if(data) {
            fputc(*data,fp);
            fclose(fp);
        }
        else
            fclose(fp);
    }
}
```

Result Information

Group: Resource management
Language: C | C++
Default: On
Command-Line Syntax: `DOUBLE_RESOURCE_CLOSE`
Impact: High
CWE ID: 672, 826, 910

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Opening previously opened resource

Opening an already opened file

Description

Opening previously opened resource checks for file opening functions that are opening an already opened file.

Risk

If you open a resource multiple times, you can encounter:

- A race condition when accessing the file.
- Undefined or unexpected behavior for that file.
- Portability issues when you run your program on different targets.

Fix

Once a resource is open, close the resource before reopening.

Examples

File Reopened With New Permissions

```
#include <stdio.h>
const char* logfile = "my_file.log";

void doubleresourceopen()
{
    FILE* fpa = fopen(logfile, "w");
    if (fpa == NULL) {
        return;
    }
    (void)fprintf(fpa, "Writing");
```

```
    FILE* fpb = fopen(logfile, "r");
    (void)fclose(fpa);
    (void)fclose(fpb);
}
```

In this example, a `logfile` is opened in the first line of this function with write privileges. Halfway through the function, the `logfile` is opened again with read privileges.

Correction — Close Before Reopening

One possible correction is to close the file before reopening the file with different privileges.

```
#include <stdio.h>
const char* logfile = "my_file.log";

void doubleresourceopen()
{
    FILE* fpa = fopen(logfile, "w");
    if (fpa == NULL) {
        return;
    }
    (void)fprintf(fpa, "Writing");
    (void)fclose(fpa);
    FILE* fpb = fopen(logfile, "r");
    (void)fclose(fpb);
}
```

Result Information

Group: Resource management
Language: C | C++
Default: On
Command-Line Syntax: `DOUBLE_RESOURCE_OPEN`
Impact: Medium
CWE ID: 362, 413, 675

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2016b

Double unlock

Unlock function is called twice in a task without an intermediate call to lock function

Description

Double unlock occurs when:

- A task calls a lock function `my_lock`.
- The task calls the corresponding unlock function `my_unlock`.
- The task calls `my_unlock` again. The task does not call `my_lock` a second time between the two calls to `my_unlock`.

In multitasking code, a lock function begins a critical section of code and an unlock function ends it. When a task `task1` calls a lock function `my_lock`, other tasks calling `my_lock` must wait until `task1` calls the corresponding unlock function. Polyspace requires that both lock and unlock functions must have the form `void func(void)`.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**.

Risk

A double unlock defect can indicate a coding error. Perhaps you wanted to call a different unlock function to end a different critical section. Perhaps you called the unlock function prematurely the first time and only the second call indicates the end of the critical section.

Fix

The fix depends on the root cause of the defect.

Identify each critical section of code, that is, the section that you want to be executed as an atomic block. Call a lock function at the beginning of the section. Only at the end of the section, call the unlock function that corresponds to the lock function. Remove any other redundant call to the unlock function.

See examples of fixes below. To avoid the issue, you can follow the practice of calling the lock and unlock functions in the same module at the same level of abstraction. For instance, in this example, `func` calls the lock and unlock function at the same level but `func2` does not.

```
void func() {
  my_lock();
  {
    ...
  }
  my_unlock();
}

void func2() {
  {
   my_lock();
   ...
  }
  my_unlock();
}
```

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Double Unlock

```
int global_var;

void BEGIN_CRITICAL_SECTION(void);
void END_CRITICAL_SECTION(void);

void task1(void)
{
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    END_CRITICAL_SECTION();
    global_var += 1;
```

```
    END_CRITICAL_SECTION();
}

void task2(void)
{
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    END_CRITICAL_SECTION();
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	Value	
Configure multitasking manually	☑	
Tasks (-entry-points)	task1 task2	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	BEGIN_CRITICAL_SECTION	END_CRITICAL_SECTION

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
  -entry-points task1,task2
  -critical-section-begin BEGIN_CRITICAL_SECTION:cs1
  -critical-section-end END_CRITICAL_SECTION:cs1
```

`task1` enters a critical section through the call `BEGIN_CRITICAL_SECTION();`. `task1` leaves the critical section through the call `END_CRITICAL_SECTION();`. `task1` calls `END_CRITICAL_SECTION` again without an intermediate call to `BEGIN_CRITICAL_SECTION`.

Correction — Remove Second Unlock

If you want the second `global_var+=1;` to be outside the critical section, one possible correction is to remove the second call to `END_CRITICAL_SECTION`. However, if other tasks are using `global_var`, this code can produce a `Data race` error.

```
int global_var;

void BEGIN_CRITICAL_SECTION(void);
void END_CRITICAL_SECTION(void);

void task1(void)
{
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    END_CRITICAL_SECTION();
    global_var += 1;
}

void task2(void)
{
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    END_CRITICAL_SECTION();
}
```

Correction — Remove First Unlock

If you want the second `global_var+=1;` to be inside the critical section, one possible correction is to remove the first call to `END_CRITICAL_SECTION`.

```
int global_var;

void BEGIN_CRITICAL_SECTION(void);
void END_CRITICAL_SECTION(void);

void task1(void)
{
```

```
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    global_var += 1;
    END_CRITICAL_SECTION();
}

void task2(void)
{
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    END_CRITICAL_SECTION();
}
```

Correction — Add Another Lock

If you want the second `global_var+=1;` to be inside a critical section, another possible correction is to add another call to `BEGIN_CRITICAL_SECTION`.

```
int global_var;

void BEGIN_CRITICAL_SECTION(void);
void END_CRITICAL_SECTION(void);

void task1(void)
{
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    END_CRITICAL_SECTION();
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    END_CRITICAL_SECTION();
}

void task2(void)
{
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    END_CRITICAL_SECTION();
}
```

Check Information

Group: Concurrency
Language: C | C++
Default: On
Command-Line Syntax: DOUBLE_UNLOCK
Impact: High
CWE ID: 765

See Also

Data race | Data race including atomic operations | Data race through standard library function call | Deadlock | Destruction of locked mutex | Double lock | Missing lock | Missing unlock

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2014b

Base class destructor not virtual

Class cannot behave polymorphically for deletion of derived class objects

Description

Base class destructor not virtual occurs when a class has `virtual` functions but not a `virtual` destructor.

Risk

The presence of `virtual` functions indicates that the class is intended for use as a base class. However, if the class does not have a `virtual` destructor, it cannot behave polymorphically for deletion of derived class objects.

If a pointer to this class refers to a derived class object, and you use the pointer to delete the object, only the base class destructor is called. Additional resources allocated in the derived class are not released and can cause a resource leak.

Fix

One possible fix is to always use a `virtual` destructor in a class that contains `virtual` functions.

Examples

Base Class Destructor Not Virtual

```
class Base {
        public:
                Base(): _b(0) {};
                virtual void update() {_b += 1;};
        private:
                int _b;
};
```

```
class Derived: public Base {
        public:
                Derived(): _d(0) {};
                ~Derived() {_d = 0;};
                virtual void update() {_d += 1;};
        private:
                int _d;
};
```

In this example, the class `Base` does not have a `virtual` destructor. Therefore, if a `Base*` pointer points to a `Derived` object that is allocated memory dynamically, and the `delete` operation is performed on that `Base*` pointer, the `Base` destructor is called. The memory allocated for the additional member `_d` is not released.

The defect appears on the base class definition. Following are some tips for navigating in the source code:

- To find classes derived from the base class, right-click the base class name and select **Search For All References**. Browse through each search result to find derived class definitions.
- To find if you are using a pointer or reference to a base class to point to a derived class object, right-click the base class name and select **Search For All References**. Browse through search results that start with `Base*` or `Base&` to locate pointers or references to the base class. You can then see if you are using a pointer or reference to point to a derived class object.

Correction — Make Base Class Destructor Virtual

One possible correction is to declare a `virtual` destructor for the class `Base`.

```
class Base {
        public:
                Base(): _b(0) {};
                virtual ~Base() {_b = 0;};
                virtual void update() {_b += 1;};
        private:
                int _b;
};

class Derived: public Base {
        public:
                Derived(): _d(0) {};
                ~Derived() {_d = 0;};
```

```
                virtual void update() {_d += 1;};
        private:
                int _d;
};
```

Result Information

Group: Object oriented
Language: C++
Default: On
Command-Line Syntax: `DTOR_NOT_VIRTUAL`
Impact: Medium

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

External Websites

CERT C++ OOP52-CPP

Introduced in R2015b

Misuse of errno

`errno` incorrectly checked for error conditions

Description

Misuse of errno occurs when you check `errno` for error conditions in situations where checking `errno` does not guarantee the absence of errors. In some cases, checking `errno` can lead to false positives.

For instance, you check `errno` following calls to the functions:

- `fopen`: If you follow the ISO® Standard, the function might not set `errno` on errors.
- `atof`: If you follow the ISO Standard, the function does not set `errno`.
- `signal`: The `errno` value indicates an error only if the function returns the `SIG_ERR` error indicator.

Risk

The ISO C Standard does not enforce that these functions set `errno` on errors. Whether the functions set `errno` or not is implementation-dependent.

To detect errors, if you check `errno` alone, the validity of this check also becomes implementation-dependent.

In some cases, the `errno` value indicates an error only if the function returns a specific error indicator. If you check `errno` before checking the function return value, you can see false positives.

Fix

For information on how to detect errors, see the documentation for that specific function.

Typically, the functions return an out-of-band error indicator to indicate errors. For instance:

- `fopen` returns a null pointer if an error occurs.
- `signal` returns the `SIG_ERR` error indicator and sets `errno` to a positive value. Check `errno` only after you have checked the function return value.

Examples

Incorrectly Checking for `errno` After `fopen` Call

```
#include <stdio.h>
#include <stdlib.h>
#include <errno.h>

#define fatal_error() abort()

const char *temp_filename = "/tmp/demo.txt";

FILE *func()
{
    FILE *fileptr;
    errno = 0;
    fileptr = fopen(temp_filename, "w+b");
    if (errno != 0) {
        if (fileptr != NULL) {
            (void)fclose(fileptr);
        }
        /* Handle error */
        fatal_error();
    }
    return fileptr;
}
```

In this example, `errno` is the first variable that is checked after a call to `fopen`. You might expect that `fopen` changes `errno` to a nonzero value if an error occurs. If you run this code with an implementation of `fopen` that does not set `errno` on errors, you might miss an error condition. In this situation, `fopen` can return a null pointer that escapes detection.

Correction — Check Return Value of `fopen` After Call

One possible correction is to only check the return value of `fopen` for a null pointer.

```
#include <stdio.h>
#include <stdlib.h>
#include <errno.h>

#define fatal_error() abort()

const char *temp_filename = "/tmp/demo.txt";

FILE *func()
{
    FILE *fileptr;
    fileptr = fopen(temp_filename, "w+b");
    if (fileptr == NULL) {
        fatal_error();
    }
    return fileptr;
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: ERRNO_MISUSE
Impact: High
CWE ID: 703

See Also

Errno not checked | Errno not reset | Returned value of a sensitive function not checked | Unsafe conversion from string to numerical value

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Errno not checked

`errno` is not checked for error conditions following function call

Description

Errno not checked occurs when you call a function that sets `errno` to indicate error conditions, but do not check `errno` after the call. For these functions, checking `errno` is the only reliable way to determine if an error occurred.

Functions that set `errno` on errors include:

- `fgetwc`, `strtol`, and `wcstol`.

  For a comprehensive list of functions, see documentation about errno.
- POSIX `errno`-setting functions such as `encrypt` and `setkey`.

Risk

To see if the function call completed without errors, check `errno` for error values.

The return values of these `errno`-setting functions do not indicate errors. The return value can be one of the following:

- `void`
- Even if an error occurs, the return value can be the same as the value from a successful call. Such return values are called in-band error indicators.

You can determine if an error occurred only by checking `errno`.

For instance, `strtol` converts a string to a long integer and returns the integer. If the result of conversion overflows, the function returns `LONG_MAX` and sets `errno` to `ERANGE`. However, the function can also return `LONG_MAX` from a successful conversion. Only by checking `errno` can you distinguish between an error and a successful conversion.

Fix

Before calling the function, set `errno` to zero.

After the function call, to see if an error occurred, compare `errno` to zero. Alternatively, compare `errno` to known error indicator values. For instance, `strtol` sets `errno` to `ERANGE` to indicate errors.

The error message in the Polyspace result shows the error indicator value that you can compare to.

Examples

`errno` Not Checked After Call to `strtol`

```
#include<stdio.h>
#include<stdlib.h>
#include<errno.h>

int main(int argc, char *argv[]) {
    char *str, *endptr;
    int base;

    str = argv[1];
    base = 10;

    long val = strtol(str, &endptr, base);
    printf("Return value of strtol() = %ld\n", val);
}
```

You are using the return value of `strtol` without checking `errno`.

Correction — Check `errno` After Call

Before calling `strtol`, set `errno` to zero . After a call to `strtol`, check the return value for `LONG_MIN` or `LONG_MAX` and `errno` for `ERANGE`.

```
#include<stdlib.h>
#include<stdio.h>
#include<errno.h>
#include<limits.h>

int main(int argc, char *argv[]) {
    char *str, *endptr;
    int base;
```

```
    str = argv[1];
    base = 10;

    errno = 0;
    long val = strtol(str, &endptr, base);
    if((val == LONG_MIN || val == LONG_MAX) && errno == ERANGE) {
         printf("strtol error");
         exit(EXIT_FAILURE);
    }
    printf("Return value of strtol() = %ld\n", val);
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: ERRNO_NOT_CHECKED
Impact: Medium
CWE ID: 253, 391

See Also

`Errno not reset` | `Misuse of errno` | `Returned value of a sensitive function not checked`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Exception caught by value

`catch` statement accepts an object by value

Description

Exception caught by value occurs when a `catch` statement accepts an object by value.

Risk

If a `throw` statement passes an object and the corresponding `catch` statement accepts the exception by value, the object is copied to the `catch` statement parameter. This copy can lead to unexpected behavior such as:

- Object slicing, if the `throw` statement passes a derived class object.
- Undefined behavior of the exception, if the copy fails.

Fix

Catch the exception by reference or by pointer. Catching an exception by reference is recommended.

Examples

Standard Exception Caught by Value

```
#include <exception>

extern void print_str(const char* p);
extern void throw_exception();

void func() {
    try {
        throw_exception();
    }
```

```
    catch(std::exception exc) {
        print_str(exc.what());
    }
}
```

In this example, the `catch` statement takes a `std::exception` object by value. Catching an exception by value causes copying of the object. It can cause undefined behavior of the exception if the copy fails.

Correction: Catch Exception by Reference

One possible solution is to catch the exception by reference.

```
#include <exception>

extern void print_str(const char* p);
extern void throw_exception();

void corrected_excpcaughtbyvalue() {
    try {
        throw_exception();
    }
    catch(std::exception& exc) {
        print_str(exc.what());
    }
}
```

Derived Class Exception Caught by Value

```
#include <exception>
#include <string>
#include <typeinfo>
#include <iostream>

// Class declarations
class BaseExc {
public:
    explicit BaseExc();
    virtual ~BaseExc() {};
protected:
    BaseExc(const std::string& type);
private:
    std::string _id;
```

```
};

class IOExc: public BaseExc {
public:
    explicit IOExc();
};

//Class method declarations
BaseExc::BaseExc():_id(typeid(this).name()) {
}
BaseExc::BaseExc(const std::string& type): _id(type) {
}
IOExc::IOExc(): BaseExc(typeid(this).name()) {
}

int input(void);

int main(void) {
    int rnd = input();
    try {
        if (rnd==0) {
            throw IOExc();
        } else {
            throw BaseExc();
        }
    }


    catch(BaseExc exc) {
        std::cout << "Intercept BaseExc" << std::endl;
    }
    return 0;
}
```

In this example, the `catch` statement takes a `BaseExc` object by value. Catching exceptions by value causes copying of the object. The copying can cause:

- Undefined behavior of the exception if it fails.
- Object slicing if an exception of the derived class `IOExc` is caught.

Correction — Catch Exceptions by Reference

One possible correction is to catch exceptions by reference.

```
#include <exception>
#include <string>
#include <typeinfo>
#include <iostream>

// Class declarations
class BaseExc {
public:
    explicit BaseExc();
    virtual ~BaseExc() {};
protected:
    BaseExc(const std::string& type);
private:
    std::string _id;
};

class IOExc: public BaseExc {
public:
    explicit IOExc();
};

//Class method declarations
BaseExc::BaseExc():_id(typeid(this).name()) {
}
BaseExc::BaseExc(const std::string& type): _id(type) {
}
IOExc::IOExc(): BaseExc(typeid(this).name()) {
}

int input(void);

int main(void) {
    int rnd = input();
    try {
        if (rnd==0) {
            throw IOExc();
        } else {
            throw BaseExc();
        }
    }



    catch(BaseExc& exc) {
```

```
        std::cout << "Intercept BaseExc" << std::endl;
    }
    return 0;
}
```

Result Information

Group: Programming
Language: C++
Default: On
Command-Line Syntax: EXCP_CAUGHT_BY_VALUE
Impact: Medium

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Exception handler hidden by previous handler

`catch` statement is not reached because of an earlier `catch` statement for the same exception

Description

Exception handler hidden by previous handler occurs when a `catch` statement is not reached because a previous `catch` statement handles the exception.

For instance, a `catch` statement accepts an object of a class `my_exception` and a later `catch` statement accepts one of the following:

- An object of the `my_exception` class.
- An object of a class derived from the `my_exception` class.

Risk

Because the `catch` statement is not reached, it is effectively dead code.

Fix

One possible fix is to remove the redundant `catch` statement.

Another possible fix is to reverse the order of `catch` statements. Place the `catch` statement that accepts the derived class exception before the `catch` statement that accepts the base class exception.

Examples

`catch` Statement Hidden by Previous Statement

```
#include <new>
```

```
extern void print_str(const char* p);
extern void throw_exception();

void func() {
    try {
        throw_exception();
    }
    catch(std::exception& exc) {
        print_str(exc.what());
    }

    catch(std::bad_alloc& exc) {
        print_str(exc.what());
    }
}
```

In this example, the second `catch` statement accepts a `std::bad_alloc` object. Because the `std::bad_alloc` class is derived from a `std::exception` class, the second `catch` statement is hidden by the previous `catch` statement that accepts a `std::exception` object.

The defect appears on the parameter type of the `catch` statement. To find which `catch` statement hides the current `catch` statement:

1. On the **Source** pane, right-click the keyword `catch` and select **Search For "catch"in Current Source File**.
2. On the **Search** pane, click each search result, proceeding backwards from the current `catch` statement. Continue until you find the `catch` statement that hides the `catch` statement with the defect.

Correction — Reorder `catch` Statement

One possible correction is to place the `catch` statement with the derived class parameter first.

```
#include <new>

extern void print_str(const char* p);
extern void throw_exception();

void corrected_excphandlerhidden() {
    try {
        throw_exception();
```

```
    }

    catch(std::bad_alloc& exc) {
        print_str(exc.what());
    }
    catch(std::exception& exc) {
        print_str(exc.what());
    }
}
```

Result Information

Group: Programming
Language: C++
Default: On
Command-Line Syntax: `EXCP_HANDLER_HIDDEN`
Impact: Medium
CWE ID: 755

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Abnormal termination of exit handler

Exit handler function interrupts the normal execution of a program

Description

Abnormal termination of exit handler looks for registered exit handlers. Exit handlers are registered with specific functions such as `atexit`, (WinAPI) `_onexit`, or `at_quick_exit()`. If the exit handler calls a function that interrupts the program's expected termination sequence, Polyspace raises a defect. Some functions that can cause abnormal exits are `exit`, `abort`, `longjmp`, or (WinAPI) `_onexit`.

Risk

If your exit handler terminates your program, you can have undefined behavior. Abnormal program termination means other exit handlers are not invoked. These additional exit handlers may do additional clean up or other required termination steps.

Fix

In inside exit handlers, remove calls to functions that prevent the exit handler from terminating normally.

Examples

Exit Handler With Call to `exit`

```
#include <stdlib.h>

volatile int some_condition = 1;
void demo_exit1(void)
{
    /* ... Cleanup code ... */
    return;
}
```

```
void exitabnormalhandler(void)
{
    if (some_condition)
    {
        /* Clean up */
        exit(0);
    }
    return;
}

int demo_install_exitabnormalhandler(void)
{

    if (atexit(demo_exit1) != 0) /* demo_exit1() performs additional cleanup */
    {
        /* Handle error */
    }
    if (atexit(exitabnormalhandler) != 0)
    {
        /* Handle error */
    }
    /* ... Program code ... */
    return 0;
}
```

In this example, `demo_install_exitabnormalhandler` registers two exit handlers, `demo_exit1` and `exitabnormalhandler`. Exit handlers are invoked in the reverse order of which they are registered. When the program ends, `exitabnormalhandler` runs, then `demo_exit1`. However, `exitabnormalhandler` calls `exit` interrupting the program exit process. Having this `exit` inside an exit handler causes undefined behavior because the program is not finished cleaning up safely.

Correction — Remove `exit` from Exit Handler

One possible correction is to let your exit handlers terminate normally. For this example, `exit` is removed from `exitabnormalhandler`, allowing the exit termination process to complete as expected.

```
#include <stdlib.h>

volatile int some_condition = 1;
void demo_exit1(void)
{
    /* ... Cleanup code ... */
```

```
    return;
}
void exitabnormalhandler(void)
{
    if (some_condition)
    {
        /* Clean up */
        /* Return normally */
    }
    return;
}

int demo_install_exitabnormalhandler(void)
{

    if (atexit(demo_exit1) != 0) /* demo_exit1() continues clean up */
    {
        /* Handle error */
    }
    if (atexit(exitabnormalhandler) != 0)
    {
        /* Handle error */
    }
    /* ... Program code ... */
    return 0;
}
```

Result Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: `EXIT_ABNORMAL_HANDLER`
Impact: Medium
CWE ID: 705

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”

“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2016b

File descriptor exposure to child process

Copied file descriptor used in multiple processes

Description

File descriptor exposure to child process occurs when a process is forked and the child process uses file descriptors inherited from the parent process.

Risk

When you fork a child process, file descriptors are copied from the parent process, which means that you can have concurrent operations on the same file. Use of the same file descriptor in the parent and child processes can lead to race conditions that may not be caught during standard debugging. If you do not properly manage the file descriptor permissions and privileges, the file content is vulnerable to attacks targeting the child process.

Fix

Check that the file has not been modified before forking the process. Close all inherited file descriptors and reopen them with stricter permissions and privileges, such as read-only permission.

Examples

File Descriptor Accessed from Forked Process

```
# include <stdio.h>
# include <stdlib.h>
# include <string.h>
# include <unistd.h>
# include <fcntl.h>
# include <sys/types.h>
# include <sys/stat.h>
```

```
const char *test_file="/home/user/test.txt";

void func(void)
{
    char c;
    pid_t pid;
    /* create file descriptor in read and write mode */
    int fd = open(test_file, O_RDWR);
    if (fd == -1)
    {
        /* Handle error */
        abort();
    }
    /* fork process */
    pid = fork();
    if (pid == -1)
    {
        /* Handle error */
        abort();
    }
    else if (pid == 0)
    {   /* Child process accesses file descriptor inherited
        from parent process */
        (void)read(fd, &c, 1);
    }
    else
    {   /* Parent process access same file descriptor as
        child process */
        (void)read(fd, &c, 1);
    }
}
```

In this example, a file descriptor `fd` is created in read and write mode. The process is then forked. The child process inherits and accesses `fd` with the same permissions as the parent process. A race condition exists between the parent and child processes. The contents of the file is vulnerable to attacks through the child process.

Correction — Close and Reopen Inherited File Descriptor

After you create the file descriptor, check the file for tampering. Then, close the inherited file descriptor in the child process and reopen it in read-only mode.

```
# include <stdio.h>
# include <stdlib.h>
# include <string.h>
# include <unistd.h>
# include <fcntl.h>
# include <sys/types.h>
# include <sys/stat.h>


const char *test_file="/home/user/test.txt";

void func(void)
{
    char c;
    pid_t pid;

    /* Get the state of file for further file tampering checking */

    /* create file descriptor in read and write mode */
    int fd = open(test_file, O_RDWR);
    if (fd == -1)
    {
        /* Handle error */
        abort();
    }

    /* Be sure the file was not tampered with while opening */

    /* fork process */

    pid = fork();
    if (pid == -1)
    {
        /* Handle error */
        (void)close(fd);
        abort();
    }
    else if (pid == 0)
    {  /* Close file descriptor in child process and repoen
```

```
        it in read only mode */

        (void)close(fd);
        fd = open(test_file, O_RDONLY);
        if (fd == -1)
        {
            /* Handle error */
            abort();
        }


        (void)read(fd, &c, 1);
        (void)close(fd);
    }
    else
    {  /* Parent acceses original file descriptor */
        (void)read(fd, &c, 1);
        (void)close(fd);
    }
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `FILE_EXPOSURE_TO_CHILD`
Impact: Medium
CWE ID: 362

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Misuse of a FILE object

Use of copy of FILE object

Description

Misuse of a FILE object occurs when:

- You dereference a pointer to a FILE object, including indirect dereference by using `memcmp()`.
- You modify an entire FILE object or one of its components through its pointer.
- You take the address of FILE object that was not returned from a call to an `fopen`-family function. No defect is raised if a macro defines the pointer as the address of a built-in FILE object, such as `#define ptr (&__stdout)`.

Risk

In some implementations, the address of the pointer to a FILE object used to control a stream is significant. A pointer to a copy of a FILE object is interpreted differently than a pointer to the original object, and can potentially result in operations on the wrong stream. Therefore, the use of a copy of a FILE object can cause the software to stop responding, which an attacker might exploit in denial-of-service attacks.

Fix

Do not make a copy of a FILE object. Do not use the address of a FILE object that was not returned from a successful call to an `fopen`-family function.

Examples

Copy of FILE Object Used in `fputs()`

```
#include <stdio.h>
#include <unistd.h>
```

```
#include <stdlib.h>
#include <string.h>
#include <strings.h>

void fatal_error(void);

int func(void)
{
    /*'stdout' dereferenced and contents
        copied to 'my_stdout'. */
    FILE my_stdout = *stdout;

    /* Address of 'my_stdout' may not point to correct stream. */
    if (fputs("Hello, World!\n", &my_stdout) == EOF)
    {
        /* Handler error */
        fatal_error();
    }
    return 0;
}
```

In this example, FILE object `stdout` is dereferenced and its contents are copied to `my_stdout`. The contents of `stdout` might not be significant. `fputs()` is then called with the address of `my_stdout` as an argument. Because no call to `fopen()` or a similar function was made, the address of `my_stdout` might not point to the correct stream.

Correction — Copy the FILE Object Pointer

Declare `my_stdout` to point to the same address as `stdout` to ensure that you write to the correct stream when you call `fputs()`.

```
#include <stdio.h>
#include <unistd.h>
#include <stdlib.h>
#include <string.h>
#include <strings.h>

void fatal_error(void);

int func(void)
{
    /* 'my_stdout' and 'stdout' point to the same object. */
```

```
    FILE *my_stdout = stdout;
    if (fputs("Hello, World!\n", my_stdout) == EOF)
    {
        /* Handler error */
        fatal_error();
    }
    return 0;
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: FILE_OBJECT_MISUSE
Impact: Low

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Incorrect syntax of flexible array member size

Flexible array member defined with size zero or one

Description

Incorrect syntax of flexible array member size occurs when you do not use the standard C syntax to define a structure with a flexible array member.

Since C99, you can define a flexible array member with an unspecified size. For instance, `desc` is a flexible array member in this example:

```
struct record {
    size_t len;
    double desc[];
};
```

Prior to C99, you might have used compiler-specific methods to define flexible arrays. For instance, you used arrays of size one or zero:

```
struct record {
    size_t len;
    double desc[0];
};
```

This usage is not compliant with the C standards following C99.

Risk

If you define flexible array members by using size zero or one, your implementation is compiler-dependent. For compilers that do not recognize the syntax, an `int` array of size one has buffer for one `int` variable. If you try to write beyond this buffer, you can run into issues stemming from array access out of bounds.

If you use the standard C syntax to define a flexible array member, your implementation is portable across all compilers conforming with the standard.

Fix

To implement a flexible array member in a structure, define an array of unspecified size. The structure must have one member besides the array and the array must be the last member of the structure.

Examples

Flexible Array Member Defined with Size One

```
#include <stdlib.h>

struct flexArrayStruct {
  int num;
  int data[1];
};

unsigned int max_size = 100;

void func(unsigned int array_size) {
  if(array_size<= 0 || array_size > max_size)
      exit(1);
  /* Space is allocated for the struct */
  struct flexArrayStruct *structP
    = (struct flexArrayStruct *)
     malloc(sizeof(struct flexArrayStruct)
          + sizeof(int) * (array_size - 1));
  if (structP == NULL) {
    /* Handle malloc failure */
    exit(2);
  }

  structP->num = array_size;

  /*
   * Access data[] as if it had been allocated
   * as data[array_size].
   */
  for (unsigned int i = 0; i < array_size; ++i) {
    structP->data[i] = 1;
  }
```

```
  free(structP);
}
```

In this example, the flexible array member `data` is defined with a size value of one. Compilers that do not recognize this syntax treat `data` as a size-one array. The statement `structP->data[i] = 1;` can write to `data` beyond the first array member and cause out of bounds array issues.

Correction — Use Standard C Syntax to Define Flexible Array

Define flexible array members with unspecified size.

```
#include <stdlib.h>

struct flexArrayStruct{
  int num;
  int data[];
};

unsigned int max_size = 100;

void func(unsigned int array_size) {
  if(array_size<=0 || array_size > max_size)
      exit(1);

  /* Allocate space for structure */
  struct flexArrayStruct *structP
    = (struct flexArrayStruct *)
    malloc(sizeof(struct flexArrayStruct)
         + sizeof(int) * array_size);

  if (structP == NULL) {
    /* Handle malloc failure */
    exit(2);
  }

  structP->num = array_size;

  /*
   * Access data[] as if it had been allocated
   * as data[array_size].
   */
  for (unsigned int i = 0; i < array_size; ++i) {
```

```
    structP->data[i] = 1;
  }

  free(structP);
}
```

Result Information

Group: Good Practice
Language:C (checker disabled if the analysis runs on C90 code indicated by the option `-c-version c90`)
Default: Off
Command-Line Syntax: `FLEXIBLE_ARRAY_MEMBER_INCORRECT_SIZE`
Impact: Low

See Also

`Hard-coded buffer size` | `Memory leak` | `Misuse of structure with flexible array member` | `Pointer access out of bounds` | `Unprotected dynamic memory allocation`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

Misuse of structure with flexible array member

Memory allocation ignores flexible array member

Description

Misuse of structure with flexible array member occurs when:

- You define an object with a flexible array member of unknown size at compilation time.
- You make an assignment between structures with a flexible array member without using `memcpy()` or a similar function.
- You use a structure with a flexible array member as an argument to a function and pass the argument by value.
- Your function returns a structure with a flexible array member.

A flexible array member has no array size specified and is the last element of a structure with at least two named members.

Risk

If the size of the flexible array member is not defined, it is ignored when allocating memory for the containing structure. Accessing such a structure has undefined behavior.

Fix

- Use `malloc()` or a similar function to allocate memory for a structure with a flexible array member.
- Use `memcpy()` or a similar function to copy a structure with a flexible array member.
- Pass a structure with a flexible array member as a function argument by pointer.

Examples

Structure Passed By Value to Function

```
#include <stddef.h>
#include <stdlib.h>
#include <string.h>
#include <stdio.h>
#include <unistd.h>


struct example_struct
{
    size_t num;
    int data[];
};

extern void arg_by_value(struct example_struct s);

void func(void)
{
    struct example_struct *flex_struct;
    size_t i;
    size_t array_size = 4;
    /* Dynamically allocate memory for the struct */
    flex_struct = (struct example_struct *)
        malloc(sizeof(struct example_struct) + sizeof(int) * array_size);
    if (flex_struct == NULL)
    {
        /* Handle error */
    }
    /* Initialize structure */
    flex_struct->num = array_size;
    for (i = 0; i < array_size; ++i)
    {
        flex_struct->data[i] = 0;
    }
    /* Handle structure */

    /* Argument passed by value. 'data' not
    copied to passed value. */
    arg_by_value(*flex_struct);
```

```
    /* Free dynamically allocated memory */
    free(flex_struct);
}
```

In this example, `flex_struct` is passed by value as an argument to `arg_by_value`. As a result, the flexible array member data is not copied to the passed argument.

Correction — Pass Structure by Pointer to Function

To ensure that all the members of the structure are copied to the passed argument, pass `flex_struct` to `arg_by_pointer` by pointer.

```
#include <stddef.h>
#include <stdlib.h>
#include <string.h>
#include <stdio.h>
#include <unistd.h>


struct example_struct
{
    size_t num;
    int data[];
};

extern void arg_by_pointer(struct example_struct *s);

void func(void)
{
    struct example_struct *flex_struct;
    size_t i;
    size_t array_size = 4;
    /* Dynamically allocate memory for the struct */
    flex_struct = (struct example_struct *)
        malloc(sizeof(struct example_struct) + sizeof(int) * array_size);
    if (flex_struct == NULL)
    {
        /* Handler error */
    }
    /* Initialize structure */
    flex_struct->num = array_size;
    for (i = 0; i < array_size; ++i)
    {
```

```
        flex_struct->data[i] = 0;
    }
    /* Handle structure */

    /* Structure passed by pointer */
    arg_by_pointer(flex_struct);

    /* Free dynamically allocated memory */
    free(flex_struct);
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: FLEXIBLE_ARRAY_MEMBER_STRUCT_MISUSE
Impact: Low

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Absorption of float operand

One addition or subtraction operand is absorbed by the other operand

Description

Absorption of float operand occurs when one operand of an addition or subtraction operation is *always* negligibly small compared to the other operand. Therefore, the result of the operation is always equal to the value of the larger operand, making the operation redundant.

Risk

Redundant operations waste execution cycles of your processor.

The absorption of a float operand can indicate design issues elsewhere in the code. It is possible that the developer expected a different range for one of the operands and did not expect the redundancy of the operation. However, the operand range is different from what the developer expects because of issues elsewhere in the code.

Fix

See if the operand ranges are what you expect. To see the ranges, place your cursor on the operation.

- If the ranges are what you expect, justify why you have the redundant operation in place. For instance, the code is only partially written and you anticipate other values for one or both of the operands from future unwritten code.

  If you cannot justify the redundant operation, remove it.
- If the ranges are not what you expect, in your code, trace back to see where the ranges come from. To begin your traceback, search for instances of the operand in your code. Browse through previous instances of the operand and determine where the unexpected range originates.

To determine when one operand is negligible compared to the other operand, the defect uses rules based on IEEE® 754 standards. To fix the defect, instead of using the actual

rules, you can use this heuristic: the ratio of the larger to the smaller operand must be less than 2^{p-1} at least for some values. Here, p is equal to 24 for 32-bit precision and 53 for 64-bit precision. To determine the precision, the defect uses your specification for `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

This defect appears only if one operand is *always* negligibly smaller than the other operand. To see instances of subnormal operands or results, use the check **Subnormal Float** in Polyspace Code Prover™.

Examples

One Addition Operand Negligibly Smaller Than The Other Operand

```
#include <stdlib.h>

float get_signal(void);
void do_operation(float);

float input_signal1(void) {
    float temp = get_signal();
    if(temp > 0. && temp < 1e-30)
        return temp;
    else {
       /* Reject value */
       exit(EXIT_FAILURE);
    }
}

float input_signal2(void) {
    float temp = get_signal();
    if(temp > 1.)
        return temp;
    else {
       /* Reject value */
       exit(EXIT_FAILURE);
    }
}

void main() {
```

```
    float signal1 = input_signal1();
    float signal2 = input_signal2();
    float super_signal = signal1 + signal2;
    do_operation(super_signal);
}
```

In this example, the defect appears on the addition because the operand `signal1` is in the range `(0,1e-30)` but `signal2` is greater than `1`.

Correction — Remove Redundant Operation

One possible correction is to remove the redundant addition operation. In the following corrected code, the operand `signal2` and its associated code is also removed from consideration.

```
#include <stdlib.h>

float get_signal(void);
void do_operation(float);

float input_signal1(void) {
    float temp = get_signal();
    if(temp > 0. && temp < 1e-30)
        return temp;
    else {
       /* Reject value */
       exit(EXIT_FAILURE);
    }
}

void main() {
    float signal1 = input_signal1();
    do_operation(signal1);
}
```

Correction — Verify Operand Range

Another possible correction is to see if the operand ranges are what you expect. For instance, if one of the operand range is not supposed to be negligibly small, fix the issue causing the small range. In the following corrected code, the range `(0,1e-2)` is imposed on `signal2` so that it is not *always* negligibly small as compared to `signal1`.

```
#include <stdlib.h>
```

```
float get_signal(void);
void do_operation(float);

float input_signal1(void) {
    float temp = get_signal();
    if(temp > 0. && temp < 1e-2)
        return temp;
    else {
       /* Reject value */
       exit(EXIT_FAILURE);
    }
}

float input_signal2(void) {
    float temp = get_signal();
    if(temp > 1.)
        return temp;
    else {
       /* Reject value */
       exit(EXIT_FAILURE);
    }
}

void main() {
    float signal1 = input_signal1();
    float signal2 = input_signal2();
    float super_signal = signal1 + signal2;
    do_operation(super_signal);
}
```

Result Information

Group: Numerical
Language: C | C++
Default: On
Command-Line Syntax: FLOAT_ABSORPTION
Impact: High
CWE ID: 189, 682, 873

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2016b

Float conversion overflow

Overflow when converting between floating point data types

Description

Float conversion overflow occurs when converting a floating point number to a smaller floating point data type. If the variable does not have enough memory to represent the original number, the conversion overflows.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Overflows can result in unpredictable values from computations. The result can be infinity or the maximum finite value depending on the rounding mode used in the implementation. If you use the result of an overflowing conversion in subsequent computations and do not account for the overflow, you can see unexpected results.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variable being converted acquires its current value You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

You can fix the defect by:

- Using a bigger data type for the result of the conversion so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

In general, avoid conversions to smaller floating point types.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Converting from `double` to `float`

```
float convert(void) {

    double diam = 1e100;
    return (float)diam;
}
```

In the return statement, the variable `diam` of type double (64 bits) is converted to a variable of type float (32 bits). However, the value 1^100 requires more than 32 bits to be precisely represented.

Check Information

Group: Numerical
Language: C | C++
Default: On
Command-Line Syntax: `FLOAT_CONV_OVFL`
Impact: High
CWE ID: 189, 197, 681

See Also

`Integer conversion overflow` | `Sign change integer conversion overflow` | `Unsigned integer conversion overflow`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Float overflow

Overflow from operation between floating points

Description

Float overflow occurs when an operation on floating point variables can result in values that cannot be represented by the result data type. The data type of a variable determines the number of bytes allocated for the variable storage and constrains the range of allowed values.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Overflows can result in unpredictable values from computations. The result can be infinity or the maximum finite value depending on the rounding mode used in the implementation. If you use the result of an overflowing computation in subsequent computations and do not account for the overflow, you can see unexpected results.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variables in the overflowing computation acquire their current values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If you do not want to fix the issue, for instance, when you handle infinities in your code, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Multiplication of Floats

```
#include <float.h>

float square(void) {

   float val = FLT_MAX;
   return val * val;
}
```

In the return statement, the variable `val` is multiplied by itself. The square of the maximum float value cannot be represented by a float (the return type for this function) because the value of `val` is the maximum float value.

Correction — Different Storage Type

One possible correction is to store the result of the operation in a larger data type. In this example, by returning a `double` instead of a `float`, the overflow defect is fixed.

```
#include <float.h>

double square(void) {
    float val = FLT_MAX;

    return (double)val * (double)val;
}
```

Check Information

Group: Numerical
Language: C | C++
Default: Off
Command-Line Syntax: `FLOAT_OVFL`
Impact: Low
CWE ID: 189, 682, 873

See Also

`Integer overflow` | `Unsigned integer overflow`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Invalid use of standard library floating point routine

Wrong arguments to standard library function

Description

Invalid use of standard library floating point routine occurs when you use invalid arguments with a floating point function from the standard library. This defect picks up:

- Rounding and absolute value routines

  `ceil, fabs, floor, fmod`
- Fractions and division routines

  `fmod, modf`
- Exponents and log routines

  `frexp, ldexp, sqrt, pow, exp, log, log10`
- Trigonometry function routines

  `cos, sin, tan, acos, asin, atan, atan2, cosh, sinh, tanh, acosh, asinh, atanh`

Risk

Domain errors on standard library floating point functions result in implementation-defined values. If you use the function return value in subsequent computations, you can see unexpected results.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the function argument acquires invalid values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using

right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

It is a good practice to handle for domain errors before using a standard library floating point function. For instance, before calling the `acos` function, check if the argument is in [-1.0, 1.0] and handle the error.

See examples of fixes below.

If you do not want to fix the issue, for instance, when you handle infinities in your code, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Arc Cosine Operation

```
#include <math.h>

double arccosine(void) {
    double degree = 5.0;
    return acos(degree);
}
```

The input value to `acos` must be in the interval `[-1,1]`. This input argument, `degree`, is outside this range.

Correction — Change Input Argument

One possible correction is to change the input value to fit the specified range. In this example, change the input value from degrees to radians to fix this defect.

```
#include <math.h>

double arccosine(void) {
    double degree = 5.0;
    double radian = degree * 3.14159 / 180.;
    return acos(radian);
}
```

Check Information

Group: Numerical
Language: C | C++
Default: On
Command-Line Syntax: `FLOAT_STD_LIB`
Impact: High
CWE ID: 227, 369, 682, 873

See Also

`Invalid use of standard library integer routine` | `Invalid use of standard library memory routine` | `Invalid use of standard library routine` | `Invalid use of standard library string routine`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Float division by zero

Dividing floating point number by zero

Description

Float division by zero occurs when the denominator of a division operation can be a zero-valued floating point number.

Risk

A division by zero can result in a program crash.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the denominator variable acquires a zero value. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

It is a good practice to check for zero values of a denominator before division and handle the error. Instead of performing the division directly:

```
res = num/den;
```

use a library function that handles zero values of the denominator before performing the division:

```
res = div(num, den);
```

See examples of fixes below.

If you do not want to fix the issue, for instance, when you handle infinities in your code, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Dividing a Floating Point Number by Zero

```
float fraction(float num)
{
    float denom = 0.0;
    float result = 0.0;

    result = num/denom;

    return result;
}
```

A division by zero error occurs at `num/denom` because `denom` is zero.

Correction — Check Before Division

```
float fraction(float num)
{
    float denom = 0.0;
    float result = 0.0;

    if( ((int)denom) != 0)
        result = num/denom;

    return result;
}
```

Before dividing, add a test to see if the denominator is zero, checking before division occurs. If `denom` is always zero, this correction can produce a dead code defect in your Polyspace results.

Correction — Change Denominator

One possible correction is to change the denominator value so that `denom` is not zero.

```
float fraction(float num)
{
    float denom = 2.0;
    float result = 0.0;

    result = num/denom;
```

```
    return result;
}
```

Check Information

Group: Numerical
Language: C | C++
Default: On
Command-Line Syntax: `FLOAT_ZERO_DIV`
Impact: High
CWE ID: 189, 369

See Also

`Integer division by zero`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Use of previously freed pointer

Memory accessed after deallocation

Description

Use of previously freed pointer occurs when you access a block of memory after freeing the block using the `free` function.

Risk

When a pointer is allocated dynamic memory with `malloc`, `calloc` or `realloc`, it points to a memory location on the heap. When you use the `free` function on this pointer, the associated block of memory is freed for reallocation. Trying to access this block of memory can result in unpredictable behavior or even a segmentation fault.

Fix

The fix depends on the root cause of the defect. See if you intended to free the memory later or allocate another memory block to the pointer before access.

As a good practice, after you free a memory block, assign the corresponding pointer to NULL. Before dereferencing pointers, check them for NULL values and handle the error. In this way, you are protected against accessing a freed block.

Examples

Use of Previously Freed Pointer Error

```
#include <stdlib.h>
#include <stdio.h>
 int increment_content_of_address(int base_val, int shift)
   {
    int j;
    int* pi = (int*)malloc(sizeof(int));
```

```
    if (pi == NULL) return 0;

    *pi = base_val;
    free(pi);

    j = *pi + shift;
    /* Defect: Reading a freed pointer */

    return j;
   }
```

The `free` statement releases the block of memory that `pi` refers to. Therefore, dereferencing`pi` after the `free` statement is not valid.

Correction — Free Pointer After Use

One possible correction is to free the pointer `pi` only after the last instance where it is accessed.

```
#include <stdlib.h>

int increment_content_of_address(int base_val, int shift)
{
    int j;
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return 0;

    *pi = base_val;

    j = *pi + shift;
    *pi = 0;

    /* Fix: The pointer is freed after its last use */
    free(pi);
    return j;
}
```

Check Information

Group: Dynamic memory
Language: C | C++
Default: On
Command-Line Syntax: FREED_PTR

Impact: High
CWE ID: 416, 825

See Also

`Deallocation of previously deallocated pointer`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Unreliable cast of function pointer

Function pointer cast to another function pointer with different argument or return type

Description

Unreliable cast of function pointer occurs when a function pointer is cast to another function pointer that has different argument or return type.

This defect applies only if the code language for the project is C.

Risk

If you cast a function pointer to another function pointer with different argument or return type and then use the latter function pointer to call a function, the behavior is undefined.

Fix

Avoid a cast between two function pointers with mismatch in argument or return types.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Unreliable cast of function pointer error

```
#include <stdio.h>
#include <math.h>
#include <stdio.h>
#define PI 3.142

double Calculate_Sum(int (*fptr)(double))
```

```
{
    double  sum = 0.0;
    double  y;

    for (int i = 0;  i <= 100;  i++)
    {
        y = (*fptr)(i*PI/100);
        sum += y;
    }
    return sum / 100;
}

int main(void)
{
    double  (*fp)(double);
    double  sum;

    fp = sin;
    sum = Calculate_Sum(fp);
    /* Defect: fp implicitly cast to int(*) (double) */

    printf("sum(sin): %f\n", sum);
    return 0;
}
```

The function pointer `fp` is declared as `double (*)(double)`. However in passing it to function `Calculate_Sum`, `fp` is implicitly cast to `int (*)(double)`.

Correction — Avoid Function Pointer Cast

One possible correction is to check that the function pointer in the definition of `Calculate_Sum` has the same argument and return type as `fp`. This step makes sure that `fp` is not implicitly cast to a different argument or return type.

```
#include <stdio.h>
#include <math.h>
#include <stdio.h>
# define PI 3.142

/*Fix: fptr has same argument and return type everywhere*/
double Calculate_Sum(double (*fptr)(double))
{
    double  sum = 0.0;
    double y;
```

```
    for (int i = 0;  i <= 100;  i++)
    {
        y = (*fptr)(i*PI/100);
        sum += y;
    }
    return sum / 100;
}

int main(void)
{
    double  (*fp)(double);
    double  sum;


    fp = sin;
    sum = Calculate_Sum(fp);
    printf("sum(sin): %f\n", sum);

    return 0;
}
```

Check Information

Group: Static memory
Language: C | C++
Default: On
Command-Line Syntax: FUNC_CAST
Impact: Medium

See Also

Unreliable cast of pointer

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Function pointer assigned with absolute address

Constant expression is used as function address is vulnerable to code injection

Description

Function pointer assigned with absolute address looks for assignments to function pointers. If the function pointer is assigned an absolute address, Bug Finder raises a defect.

Bug Finder considers expressions with any combination of literal constants as an absolute address. The one exception is when the value of the expression is zero.

Risk

Using a fixed address is not portable because it is possible the address is invalid on other platforms.

An attacker can inject code at the absolute address, causing your program to execute arbitrary, possibly malicious, code.

Fix

Do not use an absolute address with function pointers.

Examples

Function Pointer Address Assignment

```
extern int func0(int i, char c);
typedef int (*FuncPtr) (int, char);

FuncPtr funcptrabsoluteaddr() {
```

```
    return (FuncPtr)0x08040000;
}
```

In this example, the function returns a function pointer to the address `0x08040000`. If an attacker knows this absolute address, an attacker can compromise your program.

Correction — Function Address

One possible correction is to use the address of an existing function instead.

```
extern int func0(int i, char c);
typedef int (*FuncPtr) (int, char);

FuncPtr funcptrabsoluteaddr() {
    return &func0;
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `FUNC_PTR_ABSOLUTE_ADDR`
Impact: Low
CWE ID: 587

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Hard-coded buffer size

Size of memory buffer is a numerical value instead of symbolic constant

Description

Hard-coded buffer size occurs when you use a numerical value instead of a symbolic constant when declaring a memory buffer such as an array.

Risk

Hard-coded buffer size causes the following issues:

- Hard-coded buffer size increases the likelihood of mistakes and therefore maintenance costs. If a policy change requires developers to change the buffer size, they must change every occurrence of the buffer size in the code.
- Hard-constant constants can be exposed to attack if the code is disclosed.

Fix

Use a symbolic name instead of a hard-coded constant for buffer size. Symbolic names include `const`-qualified variables, `enum` constants, or macros.

`enum` constants are recommended.

- Macros are replaced by their constant values after preprocessing. Therefore, they can expose the loop boundary.
- `enum` constants are known at compilation time. Therefore, compilers can optimize the loops more efficiently.

  `const`-qualified variables are usually known at run time.

Examples

Hard-Coded Buffer Size

```
int table[100];

void read(int);

void func(void) {
    for (int i=0; i<100; i++)
        read(table[i]);
}
```

In this example, the size of the array `table` is hard-coded.

Correction — Use Symbolic Name

One possible correction is to replace the hard-coded size with a symbolic name.

```
const int MAX_1 = 100;
#define MAX_2 100
enum { MAX_3 = 100 };

int table_1[MAX_1];
int table_2[MAX_2];
int table_3[MAX_3];

void read(int);

void func(void) {
    for (int i=0; i < MAX_1; i++)
        read(table_1[i]);
    for (int i=0; i < MAX_2; i++)
        read(table_2[i]);
    for (int i=0; i < MAX_3; i++)
        read(table_3[i]);
}
```

Result Information

Group: Good practice
Language: C | C++

Default: Off
Command-Line Syntax: `HARD_CODED_BUFFER_SIZE`
Impact: Low
CWE ID: 547

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Hard-coded loop boundary

Loop boundary is a numerical value instead of symbolic constant

Description

Hard-coded loop boundary occurs when you use a numerical value instead of symbolic constant for the boundary of a `for`, `while` or `do-while` loop.

Risk

Hard-coded loop boundary causes the following issues:

- Hard-coded loop boundary makes the code vulnerable to denial of service attacks when the loop involves time-consuming computation or resource allocation.
- Hard-coded loop boundary increases the likelihood of mistakes and maintenance costs. If a policy change requires developers to change the loop boundary, they must change every occurrence of the boundary in the code.

  For instance, the loop boundary is 10000 and represents the maximum number of client connections supported in a network server application. If the server supports more clients, you must change all instances of the loop boundary in your code. Even if the loop boundary occurs once, you have to search for a numerical value of `10000` in your code. The numerical value can occur in places other than the loop boundary. You must browse through those places before you find the loop boundary.

Fix

Use a symbolic name instead of a hard-coded constant for loop boundary. Symbolic names include `const`-qualified variables, `enum` constants or macros.`enum` constants are recommended because:

- Macros are replaced by their constant values after preprocessing. Therefore, they can expose the buffer size.
- `enum` constants are known at compilation time. Therefore, compilers can allocate storage for them more efficiently.

`const`-qualified variables are usually known at run time.

Examples

Hard-Coded Loop Boundary

```
void performOperation(int);

void func(void) {
    for (int i=0; i<100; i++)
        performOperation(i);
}
```

In this example, the boundary of the `for` loop is hard-coded.

Correction — Use Symbolic Name

One possible correction is to replace the hard-coded loop boundary with a symbolic name.

```
const int MAX_1 = 100;
#define MAX_2 100
enum { MAX_3 = 100 };

void performOperation_1(int);
void performOperation_2(int);
void performOperation_3(int);

void func(void) {
    for (int i=0; i<MAX_1; i++)
        performOperation_1(i);
    for (int i=0; i<MAX_2; i++)
        performOperation_2(i);
    for (int i=0; i<MAX_3; i++)
        performOperation_3(i);
}
```

Result Information

Group: Good practice
Language: C | C++

Default: Off
Command-Line Syntax: HARD_CODED_LOOP_BOUNDARY
Impact: Low
CWE ID: 547

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Hard-coded object size used to manipulate memory

Memory manipulation with hard-coded size instead of `sizeof`

Description

Hard-coded object size used to manipulate memory occurs on constants that are memory size arguments for memory functions such as `malloc` or `memset`.

Risk

If you hard code object size, your code is not portable to architectures with different type sizes. If the constant value is not the same as the object size, the buffer might or might not overflow.

Fix

For the size argument of memory functions, use `sizeof(`*`object`*`)`.

Examples

Assume 4-Byte Integer Pointers

```
#include <stddef.h>
#include <stdlib.h>
enum {
    SIZE3   = 3,
    SIZE20  = 20
};
extern void fill_ints(int **matrix, size_t nb, size_t s);

void bug_hardcodedmemsize()
{
    size_t i, s;
```

```
    s = 4;
    int **matrix = (int **)calloc(SIZE20, s);
    if (matrix == NULL) {
        return; /* Indicate calloc() failure */
    }
    fill_ints(matrix, SIZE20, s);
    free(matrix);
}
```

In this example, the memory allocation function `calloc` is called with a memory size of 4. The memory is allocated for an integer pointer, which can be a more or less than 4 bytes depending on your target. If the integer pointer is not 4 bytes, your program can fail.

Correction — Use `sizeof(int *)`

When calling `calloc`, replace the hard-coded size with a call to `sizeof`. This change makes your code more portable.

```
#include <stddef.h>
#include <stdlib.h>
enum {
    SIZE3   = 3,
    SIZE20  = 20
};
extern void fill_ints(int **matrix, size_t nb, size_t s);

void corrected_hardcodedmemsize()
{
    size_t i, s;

    s = sizeof(int *);
    int **matrix = (int **)calloc(SIZE20, s);
    if (matrix == NULL) {
        return; /* Indicate calloc() failure */
    }
    fill_ints(matrix, SIZE20, s);
    free(matrix);
}
```

Result Information

Group: Good Practice

Language: C | C++
Default: Off
Command-Line Syntax: `HARD_CODED_MEM_SIZE`
Impact: Low
CWE ID: 805

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2016b

Improper array initialization

Incorrect array initialization when using initializers

Description

Improper array initialization occurs when Polyspace Bug Finder considers that an array initialization using initializers is incorrect.

This defect applies to normal and designated initializers. In C99, with designated initializers, you can place the elements of an array initializer in any order and implicitly initialize some array elements. The designated initializers use the array index to establish correspondence between an array element and an array initializer element. For instance, the statement `int arr[6] = { [4] = 29, [2] = 15 }` is equivalent to `int arr[6] = { 0, 0, 15, 0, 29, 0 }`.

You can use initializers incorrectly in one of the following ways.

Issue	Risk	Possible Fix
In your initializer for a one-dimensional array, you have more elements than the array size.	Unused array initializer elements indicate a possible coding error.	Increase the array size or remove excess elements.
You place the braces enclosing initializer values incorrectly.	Because of the incorrect placement of braces, some array initializer elements are not used. Unused array initializer elements indicate a possible coding error.	Place braces correctly.

Issue	Risk	Possible Fix
In your designated initializer, you do not initialize the first element of the array explicitly.	The implicit initialization of the first array element indicates a possible coding error. You possibly overlooked the fact that array indexing starts from 0.	Initialize all elements explicitly.
In your designated initializer, you initialize an element twice.	The first initialization is overridden. The redundant first initialization indicates a possible coding error.	Remove the redundant initialization.
You use designated and nondesignated initializers in the same initialization.	You or another reviewer of your code cannot determine the size of the array by inspection.	Use either designated or nondesignated initializers.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Incorrectly Placed Braces (C Only)

```
int arr[2][3]
= {{1, 2},
    {3, 4},
    {5, 6}
};
```

In this example, the array `arr` is initialized as `{1,2,0,3,4,0}`. Because the initializer contains `{5,6}`, you might expect the array to be initialized `{1,2,3,4,5,6}`.

Correction — Place Braces Correctly

One possible correction is to place the braces correctly so that all elements are explicitly initialized.

```
int a1[2][3]
= {{1, 2, 3},
    {4, 5, 6}
};
```

First Element Not Explicitly Initialized

```
int arr[5]
= {
    [1] = 2,
    [2] = 3,
    [3] = 4,
    [4] = 5
};
```

In this example, `arr[0]` is not explicitly initialized. It is possible that the programmer did not consider that the array indexing starts from 0.

Correction — Explicitly Initialize All Elements

One possible correction is to initialize all elements explicitly.

```
int arr[5]
= {
    [0] = 1,
    [1] = 2,
    [2] = 3,
    [3] = 4,
```

```
    [4] = 5
};
```

Element Initialized Twice

```
int arr[5]
= {
    [0] = 1,
    [1] = 2,
    [2] = 3,
    [2] = 4,
    [4] = 5
};
```

In this example, `arr[2]` is initialized twice. The first initialization is overridden. In this case, because `arr[3]` was not explicitly initialized, it is possible that the programmer intended to initialize `arr[3]` when `arr[2]` was initialized a second time.

Correction — Fix Redundant Initialization

One possible correction is to eliminate the redundant initialization.

```
int arr[5]
= {
    [0] = 1,
    [1] = 2,
    [2] = 3,
    [3] = 4,
    [4] = 5
};
```

Mix of Designated and Nondesignated Initializers

```
int arr[]
= {
    [0] = 1,
    [3] = 3,
    4,
    [5] = 5,
    6
    };
```

In this example, because a mix of designated and nondesignated initializers are used, it is difficult to determine the size of `arr` by inspection.

Correction — Use Only Designated Initializers

One possible correction is to use only designated initializers for array initialization.

```
int arr[]
= {
    [0] = 1,
    [3] = 3,
    [4] = 4,
    [5] = 5,
    [6] = 6
};
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `IMPROPER_ARRAY_INIT`
Impact: Medium
CWE ID: 665

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Inappropriate I/O operation on device files

Operation can result in security vulnerabilities or a system failure

Description

Inappropriate I/O operation on device files occurs when you do not check whether a file name parameter refers to a device file before you pass it to these functions:

- `fopen()`
- `fopen_s()`
- `freopen()`
- `remove()`
- `rename()`
- `CreateFile()`
- `CreateFileA()`
- `CreateFileW()`
- `_wfopen()`
- `_wfopen_s()`

Device files are files in a file system that provide an interface to device drivers. You can use these files to interact with devices.

Inappropriate I/O operation on device files does not raise a defect when:

- You use `stat` or `lstat`-family functions to check the file name parameter before calling the previously listed functions.
- You use a string comparison function to compare the file name against a list of device file names.

Risk

Operations appropriate only for regular files but performed on device files can result in denial-of-service attacks, other security vulnerabilities, or system failures.

Fix

Before you perform an I/O operation on a file:

- Use `stat()`, `lstat()`, or an equivalent function to check whether the file name parameter refers to a regular file.
- Use a string comparison function to compare the file name against a list of device file names.

Examples

Using `fopen()` Without Checking `file_name`

```
#include <stdio.h>
#include <string.h>

#define SIZE1024 1024

FILE* func()
{

    FILE* f;
    const char file_name[SIZE1024] = "./tmp/file";

    if ((f = fopen(file_name, "w")) == NULL) {
        /*handle error */
    };
    /*operate on file */
}
```

In this example, `func()` operates on the file `file_name` without checking whether it is a regular file. If `file_name` is a device file, attempts to access it can result in a system failure.

Correction — Check File with `lstat()` Before Calling `fopen()`

One possible correction is to use `lstat()` and the `S_ISREG` macro to check whether the file is a regular file. This solution contains a `File access between time of check and use (TOCTOU)` race condition that can allow an attacker to modify the file after you check it but before the call to fopen(). To prevent this vulnerability, ensure that `file_name` refers to a file in a secure folder.

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include <sys/stat.h>

#define SIZE1024 1024

FILE* func()
{

    FILE* f;
    const char file_name[SIZE1024] = "./tmp/file";
    struct stat orig_st;
    if ((lstat(file_name, &orig_st) != 0) ||
        (!S_ISREG(orig_st.st_mode))) {
        exit(0);
    }
    if ((f = fopen(file_name, "w")) == NULL) {
        /*handle error */
    };
    /*operate on file */
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `INAPPROPRIATE_IO_ON_DEVICE`
Impact: Medium
CWE ID: 67

See Also

`File access between time of check and use (TOCTOU)` | `Opening previously opened resource` | `Resource leak` | `Returned value of a sensitive function not checked` | `Vulnerable path manipulation`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

Conversion or deletion of incomplete class pointer

You delete or cast to a pointer to an incomplete class

Description

Conversion or deletion of incomplete class pointer occurs when you delete or cast to a pointer to an incomplete class. An incomplete class is one whose definition is not visible at the point where the class is used.

For instance, the definition of class `Body` is not visible when the `delete` operator is called on a pointer to `Body`:

```
class Handle {
  class Body *impl;
public:
  ~Handle() { delete impl; }
  // ...
};
```

Risk

When you delete a pointer to an incomplete class, it is not possible to call any nontrivial destructor that the class might have. If the destructor performs cleanup activities such as memory deallocation, these activities do not happen.

A similar problem happens, for instance, when you downcast to a pointer to an incomplete class (downcasting is casting from a pointer to a base class to a pointer to a derived class). At the point of downcasting, the relationship between the base and derived class is not known. In particular, if the derived class inherits from multiple classes, at the point of downcasting, this information is not available. The downcasting cannot make the necessary adjustments for multiple inheritance and the resulting pointer cannot be dereferenced.

A similar statement can be made for upcasting (casting from a pointer to derived class to a pointer to a base class).

Fix

When you delete or downcast to a pointer to a class, make sure that the class definition is visible.

Alternatively, you can perform one of these actions:

- Instead of a regular pointer, use the `std::shared_ptr` type to point to the incomplete class.
- When downcasting, make sure that the result is valid. Write error-handling code for invalid results.

Examples

Deletion of Pointer to Incomplete Class

```
class Handle {
  class Body *impl;
public:
  ~Handle() { delete impl; }
  // ...
};
```

In this example, the definition of class `Body` is not visible when the pointer to `Body` is deleted.

Correction — Define Class Before Deletion

One possible correction is to make sure that the class definition is visible when a pointer to the class is deleted.

```
class Handle {
  class Body *impl;
public:
  ~Handle();
  // ...
};

// Elsewhere
class Body { /* ... */ };
```

```
Handle::~Handle() {
  delete impl;
}
```

Correction — Use `std::shared_ptr`

Another possible correction is to use the `std::shared_ptr` type instead of a regular pointer.

```
#include <memory>

class Handle {
  std::shared_ptr<class Body> impl;
  public:
    Handle();
    ~Handle() {}
    // ...
};
```

Downcasting to Pointer to Incomplete Class

`File1.h`:

```
class Base {
protected:
  double var;
public:
  Base() : var(1.0) {}
  virtual void do_something();
  virtual ~Base();
};
```

`File2.h`:

```
void funcprint(class Derived *);
class Base *get_derived();
```

`File1.cpp`:

```
#include "File1.h"
#include "File2.h"

void getandprint() {
  Base *v = get_derived();
```

```
  funcprint(reinterpret_cast<class Derived *>(v));
}
```

`File2.cpp`:

```
#include "File2.h"
#include "File1.h"
#include <iostream>

class Base2 {
protected:
  short var2;
public:
  Base2() : var2(12) {}
};

class Derived : public Base2, public Base {
  float var_derived;
public:
    Derived() : Base2(), Base(), var_derived(1.2f) {}
    void do_something()
    {
        std::cout << "var_derived: "
                  << var_derived << ", var : " << var
                  << ", var2: " << var2 << std::endl;
    }
 };

void funcprint(Derived *d) {
  d->do_something();
}

Base *get_derived() {
  return new Derived;
}
```

In this example, the definition of class `Derived` is not visible in `File1.cpp` when a `Base*` pointer to downcast to a `Derived*` pointer.

In `File2.cpp`, class `Derived` derives from two classes, `Base` and `Base2`. This information about multiple inheritance is not available at the point of downcasting in `File1.cpp`. The result of downcasting is passed to the function `funcprint` and dereferenced in the body of `funcprint`. Because the downcasting was done with incomplete information, the dereference can be invalid.

Correction — Define Class Before Downcasting

One possible correction is to define the class `Derived` before downcasting a `Base*` pointer to a `Derived*` pointer.

In this corrected example, the downcasting is done in `File2.cpp` in the body of `funcprint` at a point where the definition of class `Derived` is visible. The downcasting is not done in `File1.cpp` where the definition of `Derived` is not visible. The changes from the previous incorrect example are highlighted.

`File1.h`:

```
class Base {
protected:
  double var;
public:
  Base() : var(1.0) {}
  virtual void do_something();
  virtual ~Base();
};
```

`File2.h`:

```
void funcprint(class Base *);
class Base *get_derived();
```

`File1.cpp`:

```
#include "File1.h"
#include "File2.h"

void getandprint() {
  Base *v = get_derived();
  funcprint(v);
}
```

`File2.cpp`:

```
#include "File2_corr.h"
#include "File1_corr.h"
#include <iostream>

class Base2 {
protected:
  short var2;
```

```
public:
  Base2() : var2(12) {}
};

class Derived : public Base2, public Base {
  float var_derived;

public:
    Derived() : Base2(), Base(), var_derived(1.2f) {}
    void do_something()
    {
        std::cout << "var_derived: "
                  << var_derived << ", var : " << var
                  << ", var2: " << var2 << std::endl;
    }
};

void funcprint(Base *d) {
  Derived *temp = dynamic_cast<Derived*>(d);
  if(temp)  {
     d->do_something();
  }
  else {
      //Handle error
  }
}

Base *get_derived() {
  return new Derived;
}
```

Result Information

Group: Object Oriented
Language: C++
Default: On
Command-Line Syntax: INCOMPLETE_CLASS_PTR
Impact: Medium

See Also

`Delete of void pointer` | `MISRA C++:2008 Rule 5-2-4` | `MISRA C++:2008 Rule 5-2-7` | `MISRA C++:2008 Rule 5-2-8`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

Use of indeterminate string

Use of buffer from fgets-family function

Description

Use of indeterminate string occurs when you do not check the validity of the buffer returned from `fgets`-family functions. The checker raises a defect when such a buffer is used as:

- An argument in standard functions that print or manipulate strings or wide strings.
- A return value.
- An argument in external functions with parameter type `const char *` or `const wchar_t *`.

Risk

If an `fgets`-family function fails, the content of its output buffer is indeterminate. Use of such a buffer has undefined behavior and can result in a program that stops working or other security vulnerabilities.

Fix

Reset the output buffer of an `fgets`-family function to a known string value when the function fails.

Examples

Output of `fgets()` Passed to External Function

```
#include <stdio.h>
#include <wchar.h>
#include <string.h>
#include <stdlib.h>
```

```
#define SIZE20 20

extern void display_text(const char *txt);

void func(void) {
    char buf[SIZE20];

    /* Check fgets() error */
    if (fgets (buf, sizeof (buf), stdin) == NULL)
    {
        /* 'buf' may contain an indeterminate string.  */
        ;
    }
    /* 'buf passed to external function */
    display_text(buf);
}
```

In this example, the output `buf` is passed to the external function `display_text()`, but its value is not reset if `fgets()` fails.

Correction — Reset `fgets()` Output on Failure

If `fgets()` fails, reset `buf` to a known value before you pass it to an external function.

```
#include <stdio.h>
#include <wchar.h>
#include <string.h>
#include <stdlib.h>

#define SIZE20 20

extern void display_text(const char *txt);

void func1(void) {
    char buf[SIZE20];
    /* Check fgets() error */
    if (fgets (buf, sizeof (buf), stdin) == NULL)
    {
        /* value of 'buf' reset after fgets() failure. */
        buf[0] = '\0';
    }
    /* 'buf' passed to external function */
```

```
    display_text(buf);
}
```

Result Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: `INDETERMINATE_STRING`
Impact: Medium

See Also

`Invalid use of standard library string routine` | `Returned value of a sensitive function not checked` | `Use of dangerous standard function`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Inline constraint not respected

Modifiable static variable is modified in nonstatic inline function

Description

Inline constraint not respected occurs when you refer to a file scope modifiable static variable or define a local modifiable static variable in a nonstatic inlined function. The checker considers a variable as modifiable if it is not `const`-qualified.

For instance, `var` is a modifiable `static` variable defined in an `inline` function `func`. `g_step` is a file scope modifiable static variable referred to in the same inlined function.

```
static int g_step;
inline void func (void) {
   static int var = 0;
   var += g_step;
}
```

Risk

When you modify a static variable in multiple function calls, you expect to modify the same variable in each call. For instance, each time you call `func`, the same instance of `var1` is incremented but a separate instance of `var2` is incremented.

```
void func(void) {
   static var1 = 0;
   var2 = 0;
   var1++;
   var2++;
}
```

If a function has an inlined and non-inlined definition (in separate files), when you call the function, the C standard allows compilers to use either the inlined or the non-inlined form (see ISO/IEC 9899:2011, sec. 6.7.4). If your compiler uses an inlined definition in one call and the non-inlined definition in another, you are no longer modifying the same variable in both calls. This behavior defies the expectations from a static variable.

Fix

Use one of these fixes:

- If you do not intend to modify the variable, declare it as `const`.

  If you do not modify the variable, there is no question of unexpected modification.
- Make the variable non-`static`. Remove the `static` qualifier from the declaration.

  If the variable is defined in the function, it becomes a regular local variable. If defined at file scope, it becomes an extern variable. Make sure that this change in behavior is what you intend.
- Make the function `static`. Add a `static` qualifier to the function definition.

  If you make the function `static`, the file with the inlined definition always uses the inlined definition when the function is called. Other files use another definition of the function. The question of which function definition gets used is not left to the compiler.

Examples

Static Variable Use in Inlined and External Definition

```
/* file1. c  : contains inline definition of get_random()*/

inline unsigned int get_random(void)
{

    static unsigned int m_z = 0xdeadbeef;
    static unsigned int m_w = 0xbaddecaf;

    /* Compute next pseudorandom value and update seeds */
    m_z = 36969 * (m_z & 65535) + (m_z >> 16);
    m_w = 18000 * (m_w & 65535) + (m_w >> 16);
    return (m_z << 16) + m_w;
}


int call_get_random(void)
{
    unsigned int rand_no;
```

```
    int ii;
    for (ii = 0; ii < 100; ii++) {
         rand_no = get_random();
    }
    rand_no = get_random();
    return 0;
}

/* file2. c  : contains external definition of get_random()*/

extern unsigned int get_random(void)
{
    /* Initialize seeds */
    static unsigned int m_z = 0xdeadbeef;
    static unsigned int m_w = 0xbaddecaf;

    /* Compute next pseudorandom value and update seeds */
    m_z = 36969 * (m_z & 65535) + (m_z >> 16);
    m_w = 18000 * (m_w & 65535) + (m_w >> 16);
    return (m_z << 16) + m_w;
}
```

In this example, `get_random()` has an inline definition in `file1.c` and an external definition in `file2.c`. When `get_random` is called in `file1.c`, compilers are free to choose whether to use the inline or the external definition.

Depending on the definition used, you might or might not modify the version of `m_z` and `m_w` in the inlined version of `get_random()`. This behavior contradicts the usual expectations from a static variable. When you call `get_random()`, you expect to always modify the same `m_z` and `m_w`.

Correction — Make Inlined Function Static

One possible correction is to make the inlined `get_random()` static. Irrespective of your compiler, calls to `get_random()` in `file1.c` then use the inlined definition. Calls to `get_random()` in other files use the external definition. This fix removes the ambiguity about which definition is used and whether the static variables in that definition are modified.

```
/* file1. c  : contains inline definition of get_random()*/

static inline unsigned int get_random(void)
{
```

```
    static unsigned int m_z = 0xdeadbeef;
    static unsigned int m_w = 0xbaddecaf;

    /* Compute next pseudorandom value and update seeds */
    m_z = 36969 * (m_z & 65535) + (m_z >> 16);
    m_w = 18000 * (m_w & 65535) + (m_w >> 16);
    return (m_z << 16) + m_w;
}


int call_get_random(void)
{
    unsigned int rand_no;
    int ii;
    for (ii = 0; ii < 100; ii++) {
         rand_no = get_random();
    }
    rand_no = get_random();
    return 0;
}

/* file2. c  : contains external definition of get_random()*/

extern unsigned int get_random(void)
{
    /* Initialize seeds */
    static unsigned int m_z = 0xdeadbeef;
    static unsigned int m_w = 0xbaddecaf;

    /* Compute next pseudorandom value and update seeds */
    m_z = 36969 * (m_z & 65535) + (m_z >> 16);
    m_w = 18000 * (m_w & 65535) + (m_w >> 16);
    return (m_z << 16) + m_w;
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: INLINE_CONSTRAINT_NOT_RESPECTED
Impact: Medium

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Integer constant overflow

Constant value falls outside range of integer data type

Description

Integer constant overflow occurs when you assign a compile-time constant to a signed integer variable whose data type cannot accommodate the value. An `n`-bit signed integer holds values in the range $[-2^{n-1}, 2^{n-1}-1]$.

For instance, `c` is an 8-bit signed `char` variable that cannot hold the value 255.

```
signed char c = 255;
```

To determine the sizes of fundamental types, Bug Finder uses your specification for `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

The default behavior for constant overflows can vary between compilers and platforms. Retaining constant overflows can reduce the portability of your code.

Even if your compilers wraps around overflowing constants with a warning, the wrap-around behavior can be unintended and cause unexpected results.

Fix

Check if the constant value is what you intended. If the value is correct, use a different, possibly wider, data type for the variable.

Examples

Overflowing Constant from Macro Expansion

```
#define MAX_UNSIGNED_CHAR 255
#define MAX_SIGNED_CHAR 127
```

```
void main() {
    char c1 = MAX_UNSIGNED_CHAR;
    char c2 = MAX_SIGNED_CHAR+1;
}
```

In this example, the defect appears on the macros because at least one use of the macro causes an overflow. To reproduce these defects, use a `Target processor type (-target)` where `char` is signed by default. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Correction — Use Different Data Type

One possible correction is to use a different data type for the variables that overflow.

```
#define MAX_UNSIGNED_CHAR 255
#define MAX_SIGNED_CHAR 127

void main() {
    unsigned char c1 = MAX_UNSIGNED_CHAR;
    unsigned char c2 = MAX_SIGNED_CHAR+1;
}
```

Result Information

Group: Numerical
Language: C | C++
Default: Off
Command-Line Syntax: `INT_CONSTANT_OVFL`
Impact: Medium
CWE ID: 128, 189, 190, 191

See Also

`Integer conversion overflow` | `Integer overflow` | `Sign change integer conversion overflow` | `Unsigned integer constant overflow` | `Unsigned integer conversion overflow` | `Unsigned integer overflow`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

Integer conversion overflow

Overflow when converting between integer types

Description

Integer conversion overflow occurs when converting an integer to a smaller integer type. If the variable does not have enough bytes to represent the original value, the conversion overflows.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Integer conversion overflows result in undefined behavior.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variables in the overflowing computation acquire their current values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

You can fix the defect by:

- Using a bigger data type for the result of the conversion so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

In general, avoid conversions to smaller integer types.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Converting from `int` to `char`

```
char convert(void) {

    int num = 1000000;

    return (char)num;
}
```

In the return statement, the integer variable `num` is converted to a `char`. However, an 8-bit or 16-bit character cannot represent 1000000 because it requires at least 20 bits. So the conversion operation overflows.

Correction — Change Conversion Type

One possible correction is to convert to a different integer type that can represent the entire number.

```
long convert(void) {

    int num = 1000000;

    return (long)num;
}
```

Check Information

Group: Numerical
Language: C | C++
Default: On
Command-Line Syntax: `INT_CONV_OVFL`
Impact: High
CWE ID: 128, 189, 190, 191, 192, 197

See Also

`Float conversion overflow` | `Sign change integer conversion overflow` | `Unsigned integer conversion overflow`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Integer overflow

Overflow from operation between integers

Description

Integer overflow occurs when an operation on integer variables can result in values that cannot be represented by the result data type. The data type of a variable determines the number of bytes allocated for the variable storage and constrains the range of allowed values.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Integer overflows on signed integers result in undefined behavior.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variables in the overflowing computation acquire their current values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

You can fix the defect by:

- Using a bigger data type for the result of the operation so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

To avoid overflows in general, try one of these techniques:

- Keep integer variable values restricted to within half the range of signed integers.
- In operations that might overflow, check for conditions that can lead to the overflow and implement wrap around or saturation behavior depending on how the result of the operation is used. The result then becomes predictable and can be safely used in subsequent computations.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Addition of Maximum Integer

```
#include <limits.h>

int plusplus(void) {

    int var = INT_MAX;
    var++;
    return var;
}
```

In the third statement of this function, the variable `var` is increased by one. But the value of `var` is the maximum integer value, so an `int` cannot represent one plus the maximum integer value.

Correction — Different Storage Type

One possible correction is to change data types. Store the result of the operation in a larger data type (Note that on a 32-bit machine, `int` and `long` has the same size). In this example, on a 32-bit machine, by returning a `long long` instead of an `int`, the overflow error is fixed.

```
#include <limits.h>

long long plusplus(void) {

    long long lvar = INT_MAX;
```

```
    lvar++;
    return lvar;
}
```

Check Information

Group: Numerical
Language: C | C++
Default: Off
Command-Line Syntax: `INT_OVFL`
Impact: Medium
CWE ID: 128, 189, 190, 191, 192

See Also

`Float overflow` | `Unsigned integer overflow`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Integer precision exceeded

Operation using integer size instead of precision can cause undefined behavior

Description

Integer precision exceeded occurs when an integer expression uses the integer size in an operation that exceeds the integer precision. On some architectures, the size of an integer in memory can include sign and padding bits. On these architectures, the integer size is larger than the precision which is just the number of bits that represent the value of the integer.

Risk

Using the size of an integer in an operation on the integer precision can result in integer overflow, wrap around, or unexpected results. For instance, an unsigned integer can be stored in memory in 64 bits, but uses only 48 bits to represent its value. A 56 bits left-shift operation on this integer is undefined behavior.

Assuming that the size of an integer is equal to its precision can also result in program portability issues between different architectures.

Fix

Do not use the size of an integer instead of its precision. To determine the integer precision, implement a precision computation routine or use a builtin function such as `__builtin_popcount()`.

Examples

Using Size of `unsigned int` for Left Shift Operation

```
#include <limits.h>

unsigned int func(unsigned int exp)
```

```
{
    if (exp >= sizeof(unsigned int) * CHAR_BIT) {
        /* Handle error */
    }
    return 1U << exp;
}
```

In this example, the function uses a left shift operation to return the value of 2 raised to the power of `exp`. The operation shifts the bits of `1U` by `exp` positions to the left. The `if` statement ensures that the operation does not shift the bits by a number of positions `exp` greater than the size of an `unsigned int`. However, if `unsigned int` contains padding bits, the value returned by `sizeof()` is larger than the precision of `unsigned int`. As a result, some values of `exp` might be too large, and the shift operation might be undefined behavior.

Correction — Implement Function to Compute Precision of `unsigned int`

One possible correction is to implement a function `popcount()` that computes the precision of `unsigned int` by counting the number of set bits.

```
#include <stddef.h>
#include <stdint.h>
#include <limits.h>

size_t popcount(uintmax_t);
#define PRECISION(umax_value) popcount(umax_value)


unsigned int func(unsigned int exp)
{
    if (exp >= PRECISION(UINT_MAX)) {
        /* Handle error */
    }
    return 1 << exp;
}




size_t popcount(uintmax_t num)
{
    size_t precision = 0;
    while (num != 0) {
        if (num % 2 == 1) {
```

```
            precision++;
        }
        num >>= 1;
    }
    return precision;
}
```

Result Information

Group: Numerical
Language: C | C++
Default: Off
Command-Line Syntax: INT_PRECISION_EXCEEDED
Impact: Low
CWE ID: 190

See Also

Bitwise operation on negative value | Integer conversion overflow | Integer overflow | MISRA C:2012 Rule 10.1 | MISRA C:2012 Rule 10.2 | Possible invalid operation on boolean operand | Shift of a negative value | Shift operation overflow | Unsigned integer conversion overflow | Unsigned integer overflow

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

Invalid use of standard library integer routine

Wrong arguments to standard library function

Description

Invalid use of standard library integer routine occurs when you use invalid arguments with an integer function from the standard library. This defect picks up:

- Character Conversion

  ```
  toupper, tolower
  ```

- Character Checks

  ```
  isalnum, isalpha, iscntrl, isdigit, isgraph, islower, isprint,
  ispunct, isspace, isupper, isxdigit
  ```

- Integer Division

  ```
  div, ldiv
  ```

- Absolute Values

  ```
  abs, labs
  ```

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Absolute Value of Large Negative

```
#include <limits.h>
#include <stdlib.h>

int absoluteValue(void) {

    int neg = INT_MIN;
    return abs(neg);
}
```

The input value to `abs` is `INT_MIN`. The absolute value of `INT_MIN` is `INT_MAX+1`. This number cannot be represented by the type `int`.

Correction — Change Input Argument

One possible correction is to change the input value to fit returned data type. In this example, change the input value to `INT_MIN+1`.

```
#include <limits.h>
#include <stdlib.h>

int absoluteValue(void) {

    int neg = INT_MIN+1;
    return abs(neg);
}
```

Check Information

Group: Numerical
Language: C | C++
Default: On
Command-Line Syntax: `INT_STD_LIB`
Impact: High
CWE ID: 227, 369, 682, 872

See Also

`Invalid use of standard library floating point routine` | `Invalid use of standard library memory routine` | `Invalid use of standard library routine` | `Invalid use of standard library string routine`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Precision loss in integer to float conversion

Least significant bits of integer lost during conversion to floating-point type

Description

Precision loss from integer to float conversion occurs when you cast an integer value to a floating-point type that cannot represent the original integer value.

For instance, the `long int` value `1234567890L` is too large for a variable of type `float` .

Risk

If the floating-point type cannot represent the integer value, the behavior is undefined (see C11 standard, 6.3.1.4, paragraph 2). For instance, least significant bits of the variable value can be dropped leading to unexpected results.

Fix

Convert to a floating-point type that can represent the integer value.

For instance, if the `float` data type cannot represent the integer value, use the `double` data type instead.

When writing a function that converts an integer to floating point type, before the conversion, check if the integer value can be represented in the floating-point type. For instance, `DBL_MANT_DIG * log2(FLT_RADIX)` represents the number of base-2 digits in the type `double`. Before conversion to the type `double`, check if this number is greater than or equal to the precision of the integer that you are converting. To determine the precision of an integer `num`, use this code:

```
size_t precision = 0;
while (num != 0) {
   if (num % 2 == 1) {
     precision++;
   }
```

```
    num >>= 1;
 }
```

Some implementations provide a builtin function to determine the precision of an integer. For instance, GCC provides the function `__builtin_popcount`.

Examples

Conversion of Large Integer to Floating-Point Type

```
#include <stdio.h>

int main(void) {
  long int big = 1234567890L;
  float approx = big;
  printf("%ld\n", (big - (long int)approx));
  return 0;
}
```

In this example, the `long int` variable `big` is converted to `float`.

Correction — Use a Wider Floating-Point Type

One possible correction is to convert to the `double` data type instead of `float`.

```
#include <stdio.h>

int main(void) {
  long int big = 1234567890L;
  double approx = big;
  printf("%ld\n", (big - (long int)approx));
  return 0;
}
```

Result Information

Group: Numerical
Language: C | C++
Default: Off
Command-Line Syntax: `INT_TO_FLOAT_PRECISION_LOSS`

Impact: Low
CWE ID: 189, 681, 704

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

Integer division by zero

Dividing integer number by zero

Description

Integer division by zero occurs when the denominator of a division or modulo operation can be a zero-valued integer.

Risk

A division by zero can result in a program crash.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the denominator variable acquires a zero value. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

It is a good practice to check for zero values of a denominator before division and handle the error. Instead of performing the division directly:

```
res = num/den;
```

use a library function that handles zero values of the denominator before performing the division:

```
res = div(num, den);
```

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Dividing an Integer by Zero

```
int fraction(int num)
{
    int denom = 0;
    int result = 0;

    result = num/denom;

    return result;
}
```

A division by zero error occurs at `num/denom` because `denom` is zero.

Correction — Check Before Division

```
int fraction(int num)
{
    int denom = 0;
    int result = 0;

    if (denom != 0)
        result = num/denom;

    return result;
}
```

Before dividing, add a test to see if the denominator is zero, checking before division occurs. If `denom` is always zero, this correction can produce a dead code defect in your Polyspace results.

Correction — Change Denominator

One possible correction is to change the denominator value so that `denom` is not zero.

```
int fraction(int num)
{
    int denom = 2;
    int result = 0;

    result = num/denom;
```

```
    return result;
}
```

Modulo Operation with Zero

```
int mod_arr(int input)
{
    int arr[5];
    for(int i = 0; i < 5; i++)
    {
        arr[i] = input % i;
    }

    return arr[0]+arr[1]+arr[2]+arr[3]+arr[4];
}
```

In this example, Polyspace flags the modulo operation as a division by zero. Because modulo is inherently a division operation, the divisor (right hand argument) cannot be zero. The modulo operation uses the `for` loop index as the divisor. However, the `for` loop starts at zero, which cannot be an iterator.

Correction — Check Divisor Before Operation

One possible correction is checking the divisor before the modulo operation. In this example, see if the index `i` is zero before the modulo operation.

```
int mod_arr(int input)
{
    int arr[5];
    for(int i = 0; i < 5; i++)
    {
        if(i != 0)
        {
             arr[i] = input % i;
        }
        else
        {
             arr[i] = input;
        }
    }

    return arr[0]+arr[1]+arr[2]+arr[3]+arr[4];
}
```

Correction — Change Divisor

Another possible correction is changing the divisor to a nonzero integer. In this example, add one to the index before the `%` operation to avoid dividing by zero.

```
int mod_arr(int input)
{
    int arr[5];
    for(int i = 0; i < 5; i++)
    {
         arr[i] = input % (i+1);
    }

    return arr[0]+arr[1]+arr[2]+arr[3]+arr[4];
}
```

Check Information

Group: Numerical
Language: C | C++
Default: On
Command-Line Syntax: `INT_ZERO_DIV`
Impact: High
CWE ID: 189, 369

See Also

`Float division by zero`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Environment pointer invalidated by previous operation

Call to `setenv` or `putenv` family function modifies environment pointed to by pointer

Description

Environment pointer invalidated by previous operation occurs when you use the third argument of *main()* in a hosted environment to access the environment after an operation modifies the environment. In a hosted environment, many C implementations support the nonstandard syntax:

```
main (int argc, char *argv[], char *envp[])
```

A call to a `setenv` or `putenv` family function modifies the environment pointed to by `*envp`.

Risk

When you modify the environment through a call to a `setenv` or `putenv` family function, the environment memory can potentially be reallocated. The hosted environment pointer is not updated and might point to an incorrect location. A call to this pointer can return unexpected results or cause an abnormal program termination.

Fix

Do not use the hosted environment pointer. Instead, use global external variable `environ` in Linux®, `_environ` or `_wenviron` in Windows, or their equivalent. When you modify the environment, these variables are updated.

Examples

Access Environment Through Pointer envp

```
#include <stdio.h>
#include <stdlib.h>
```

```
extern int check_arguments(int argc, char **argv, char **envp);
extern void use_envp(char **envp);

/* envp is from main function */
int func(char **envp)
{
    /* Call to setenv may cause environment
     *memory to be reallocated
     */
    if (setenv(("MY_NEW_VAR"),("new_value"),1) != 0)
    {
        /* Handle error */
        return -1;
    }
    /* envp not updated after call to setenv, and may
     *point to incorrect location.
     **/
    if (envp != ((void *)0)) {
        use_envp(envp);
/* No defect on second access to
*envp because defect already raised */
    }
    return 0;
}

void  main(int argc, char **argv, char **envp)
{
    if (check_arguments(argc, argv, envp))
    {
        (void)func(envp);
    }
}
```

In this example, `envp` is accessed inside `func()` after a call to `setenv` that can reallocate the environment memory. `envp` can point to an incorrect location because it is not updated after `setenv` modifies the environment. No defect is raised when `use_envp()` is called because the defect is already raised on the previous line of code.

Correction — Use Global External Variable `environ`

One possible correction is to access the environment by using a variable that is always updated after a call to `setenv`. For instance, in the following code, the pointer `envp` is

still available from `main()`, but the environment is accessed in `func()` through the global external variable `environ`.

```
#include <stdio.h>
#include <stdlib.h>
extern char **environ;

extern int check_arguments(int argc, char **argv, char **envp);
extern void use_envp(char **envp);

int func(void)
{
    if (setenv(("MY_NEW_VAR"), ("new_value"),1) != 0) {
        /* Handle error */
        return -1;
    }
  /* Use global external variable environ
   *which is always updated after a call to setenv */

    if (environ != NULL) {
        use_envp(environ);
    }
    return 0;
}

void  main(int argc, char **argv, char **envp)
{
    if (check_arguments(argc, argv, envp))
    {
        (void)func();
    }
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `INVALID_ENV_POINTER`
Impact: Medium
CWE ID: 825

See Also

`Misuse of return value from nonreentrant standard function` | `Modification of internal buffer returned from nonreentrant standard function`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Invalid file position

`fsetpos()` is invoked with a file position argument not obtained from `fgetpos()`

Description

Invalid file position occurs when the file position argument of `fsetpos()` uses a value that is not obtained from `fgetpos()`.

Risk

The function `fgetpos(FILE *stream, fpos_t *pos)` gets the current file position of the stream. When you use any other value as the file position argument of `fsetpos(FILE *stream, const fpos_t *pos)`, you might access an unintended location in the stream.

Fix

Use the value returned from a successful call to `fgetpos()` as the file position argument of `fsetpos()`.

Examples

`memset()` Sets File Position Argument

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>


FILE *func(FILE *file)
{
    fpos_t offset;
    if (file == NULL)
    {
        /* Handle error */
```

```
    }
    /* Store initial position in variable 'offset' */
    (void)memset(&offset, 0, sizeof(offset));

    /* Read data from file */

    /* Return to the initial position. offset was not
    returned from a call to fgetpos()    */
    if (fsetpos(file, &offset) != 0)
    {
        /* Handle error */
    }
    return file;
}
```

In this example, `fsetpos()` uses `offset` as its file position argument. However, the value of `offset` is set by `memset()`. The preceding code might access the wrong location in the stream.

Correction — Use a File Position Returned From `fgetpos()`

Call `fgetpos()`, and if it returns successfully, use the position argument in your call to `fsetpos()`.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

FILE *func(FILE *file)
{
    fpos_t offset;
    if (file == NULL)
    {
        /* Handle error */
    }
    /* Store initial position in variable 'offset'
    using fgetpos() */
    if (fgetpos(file, &offset) != 0)
    {
        /* Handle error */
    }
```

```
    /* Read data from file */

    /* Back to the initial position */
    if (fsetpos(file, &offset) != 0)
    {
        /* Handle error */
    }
    return file;
}
```

Result Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: `INVALID_FILE_POS`
Impact: Medium

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Invalid assumptions about memory organization

Address is computed by adding or subtracting from address of a variable

Description

Invalid assumptions about memory organization occurs when you compute the address of a variable in the stack by adding or subtracting from the address of another non-array variable.

Risk

When you compute the address of a variable in the stack by adding or subtracting from the address of another variable, you assume a certain memory organization. If your assumption is incorrect, accessing the computed address can be invalid.

Fix

Do not perform an access that relies on assumptions about memory organization.

Examples

Reliance on Memory Organization

```
void func(void) {
    int var1 = 0x00000011, var2;
    *(&var1 + 1) = 0;
}
```

In this example, the programmer relies on the assumption that `&var1 + 1` provides the address of `var2`. Therefore, an **Invalid assumptions about memory organization** appears on the + operation. In addition, a **Pointer access out of bounds** error also appears on the dereference.

Correction — Do Not Rely on Memory Organization

One possible correction is not perform direct computation on addresses to access separately declared variables.

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `INVALID_MEMORY_ASSUMPTION`
Impact: Medium
CWE ID: 188

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Possible invalid operation on boolean operand

Operation can exceed precision of Boolean operand or result in arbitrary value

Description

Possible invalid operation on boolean operand occurs when you use a Boolean operand in an arithmetic, relational, or bitwise operation and:

- The Boolean operand has a trap representation. The size of a Boolean type in memory is at least one addressable unit (size of `char`). A Boolean type requires only one bit to represent the value `true (1)` or `false (0)`. The representation of a Boolean operand in memory contains padding bits. The memory representation can result in values that are not `true` or `false`, a trap representation.
- The result of the operation can exceed the precision of the Boolean operand.

For example, in this code snippet:

```
bool_v >> 2
```

- If the value of `bool_v` is `true (1)` or `false (0)`, the bitwise shift exceeds the one-bit precision of `bool_v` and always results in `0`.
- If `bool_v` has a trap representation, the result of the operation is an arbitrary value.

Possible invalid operation on boolean operand raises no defect when:

- The operation does not result in a precision overflow. For instance, bitwise & or `|` operations with `0x01` or `0x00`.
- The Boolean operand cannot have a trap representation. For instance, a constant expression that results in `0` or `1`, or a comparison evaluated to `true` or `false`.

Risk

Arithmetic, relational, or bitwise operations on a Boolean operand can exceed the operand precision and cause unexpected results when used as a Boolean value. Operations on Boolean operands with trap representations can return arbitrary values.

Fix

Avoid performing operations on Boolean operands other than these operations:

- Assignment operation (=).
- Equality operations (== or !=).
- Logical operations (&&, ||, or !).

Examples

Possible Trap Representation of Boolean Operand

```
#include <stdio.h>
#include <stdbool.h>

#define BOOL _Bool

int arr[2] = {1, 2};

int func(BOOL b)
{
    return arr[b];
}

int main(void)
{
    BOOL b;
    char* ptr = (char*)&b;
    *ptr = 64;
    return func(b);
}
```

In this example, Boolean operand `b` is used as an array index in `func` for an array with two elements. Depending on the compiler and optimization flags you use, the value `b` might not be `0` or `1`. For instance, in Linux Debian 8, if you use `gcc` version 4.9 with optimization flag `-O0`, the value of `b` is 64, which causes a buffer overflow.

Correction — Use Only Last Significant Bit Value of Boolean Operand

One possible correction is to use a variable `b0` of type `unsigned int` to get only the value of the last significant bit of the Boolean operand. The value of this bit is in the range `[0..1]`, even if the Boolean operand has a trap representation.

```
#include <stdio.h>
#include <stdbool.h>

#define BOOL _Bool

int arr[2] = {1, 2};

int func(BOOL b)
{
    unsigned int b0 = (unsigned int)b;
    b0 &= 0x1;
    return arr[b0];
}

int main(void)
{
    BOOL b;
    char* ptr = (char*)&b;
    *ptr = 64;
    return func(b);
}
```

Result Information

Group: Numerical
Language: C | C++
Default: Off
Command-Line Syntax: `INVALID_OPERATION_ON_BOOLEAN`
Impact: Low
CWE ID: 190

See Also

`Bitwise and arithmetic operation on the same data` | `Bitwise operation on negative value` | `Integer conversion overflow` | `Integer overflow` | `Integer precision exceeded` | `MISRA C++:2008 Rule 4-5-2` | `MISRA C:2012`

`Rule 10.1|MISRA C:2012 Rule 12.2|Shift of a negative value|Shift operation overflow|Unsigned integer conversion overflow|Unsigned integer overflow`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

Invalid va_list argument

Variable argument list used after invalidation with `va_end` or not initialized with `va_start` or `va_copy`

Description

Invalid va_list argument occurs when you use a `va_list` variable as an argument to a function in the `vprintf` group but:

- You do not initialize the variable previously using `va_start` or `va_copy`.
- You invalidate the variable previously using `va_end` and do not reinitialize it.

For instance, you call the function `vsprintf` as `vsprintf (buffer,format, args)`. However, before the function call, you do not initialize the `va_list` variable `args` using either of the following:

- `va_start(args, paramName)`. `paramName` is the last named argument of a variable-argument function. For instance, for the function definition `void func(int n, char c, ...) {}`, `c` is the last named argument.
- `va_copy(args, anotherList)`. `anotherList` is another valid `va_list` variable.

Risk

The behavior of an uninitialized `va_list` argument is undefined. Calling a function with an uninitialized `va_list` argument can cause stack overflows.

Fix

Before using a `va_list` variable as function argument, initialize it with `va_start` or `va_copy`.

Clean up the variable using `va_end` only after all uses of the variable.

Examples

`va_list` Variable Used Following Call to `va_end`

```
#include <stdarg.h>
#include <stdio.h>

int call_vfprintf(int line, const char *format, ...) {
    va_list ap;
    int r=0;

    va_start(ap, format);
    r = vfprintf(stderr, format, ap);
    va_end(ap);

    r += vfprintf(stderr, format, ap);
    return r;
}
```

In this example, the `va_list` variable `ap` is used in the `vfprintf` function, after the `va_end` macro is called.

Correction — Call `va_end` After Using `va_list` Variable

One possible correction is to call `va_end` only after all uses of the `va_list` variable.

```
#include <stdarg.h>
#include <stdio.h>

int call_vfprintf(int line, const char *format, ...) {
    va_list ap;
    int r=0;

    va_start(ap, format);
    r = vfprintf(stderr, format, ap);
    r += vfprintf(stderr, format, ap);
    va_end(ap);

    return r;
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `INVALID_VA_LIST_ARG`
Impact: High
CWE ID: 628

See Also

`Incorrect data type passed to va_arg`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Alternating input and output from a stream without flush or positioning call

Undefined behavior for input or output stream operations

Description

Alternating input and output from a stream without flush or positioning call occurs when:

- You do not perform a flush or function positioning call between an output operation and a following input operation on a file stream in update mode.
- You do not perform a function positioning call between an input operation and a following output operation on a file stream in update mode.

Risk

Alternating input and output operations on a stream without an intervening flush or positioning call is undefined behavior.

Fix

Call `fflush()` or a file positioning function such as `fseek()` or `fsetpos()` between output and input operations on an update stream.

Call a file positioning function between input and output operations on an update stream.

Examples

Read After Write Without Intervening Flush

```
#include <stdio.h>
#define SIZE20 20
```

```
void initialize_data(char* data, size_t s) {};
const char *temp_filename = "/tmp/demo.txt";

void func()
{
    char data[SIZE20];
    char append_data[SIZE20];
    FILE *file;

    file = fopen(temp_filename, "a+");
    if (file == NULL)
      {
        /* Handle error. */;
      }

    initialize_data(append_data, SIZE20);

    if (fwrite(append_data, 1, SIZE20, file) != SIZE20)
      {
        (void)fclose(file);
        /* Handle error. */;
      }
    /* Read operation after write without
    intervening flush. */
    if (fread(data, 1, SIZE20, file) < SIZE20)
      {
          (void)fclose(file);
          /* Handle error. */;
      }

    if (fclose(file) == EOF)
      {
        /* Handle error. */;
      }
}
```

In this example, the file `demo.txt` is opened for reading and appending. After the call to `fwrite()`, a call to `fread()` without an intervening flush operation is undefined behavior.

Correction — Call `fflush()` Before the Read Operation

After writing data to the file, before calling `fread()`, perform a flush call.

```
#include <stdio.h>
#define SIZE20 20

void initialize_data(char* data, size_t s) {};
const char *temp_filename = "/tmp/demo.txt";


void func()
{
    char data[SIZE20];
    char append_data[SIZE20];
    FILE *file;

    file = fopen(temp_filename, "a+");
    if (file == NULL)
      {
        /* Handle error. */;
      }

    initialize_data(append_data, SIZE20);

    if (fwrite(append_data, 1, SIZE20, file) != SIZE20)
      {
        (void)fclose(file);
        /* Handle error. */;
      }
    /* Buffer flush after write and before read */
    if (fflush(file) != 0)
      {
        (void)fclose(file);
        /* Handle error. */;
      }
    if (fread(data, 1, SIZE20, file) < SIZE20)
      {
        (void)fclose(file);
        /* Handle error. */;
      }

    if (fclose(file) == EOF)
      {
        /* Handle error. */;
```

```
        }
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `IO_INTERLEAVING`
Impact: Low

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Pointer or reference to stack variable leaving scope

Pointer to local variable leaves the variable scope

Description

Pointer or reference to stack variable leaving scope occurs when a pointer or reference to a local variable leaves the scope of the variable. For instance:

- A function returns a pointer to a local variable.
- A function performs the assignment `globPtr = &locVar`. `globPtr` is a global pointer variable and `locVar` is a local variable.
- A function performs the assignment `*paramPtr = &locVar`. `paramPtr` is a function parameter that is, for instance, an `int**` pointer and `locVar` is a local `int` variable.
- A C++ method performs the assignment `memPtr = &locVar`. `memPtr` is a pointer data member of the class the method belongs to. `locVar` is a variable local to the method.

The defect also applies to memory allocated using the `alloca` function. The defect does not apply to static, local variables.

Risk

Local variables are allocated an address on the stack. Once the scope of a local variable ends, this address is available for reuse. Using this address to access the local variable value outside the variable scope can cause unexpected behavior.

If a pointer to a local variable leaves the scope of the variable, Polyspace Bug Finder highlights the defect. The defect appears even if you do not use the address stored in the pointer. For maintainable code, it is a good practice to not allow the pointer to leave the variable scope. Even if you do not use the address in the pointer now, someone else using your function can use the address, causing undefined behavior.

Fix

Do not allow a pointer or reference to a local variable to leave the variable scope.

Examples

Pointer to Local Variable Returned from Function

```
void func2(int *ptr) {
    *ptr = 0;
}

int* func1(void) {
    int ret = 0;
    return &ret ;
}
void main(void) {
    int* ptr = func1() ;
    func2(ptr) ;
}
```

In this example, `func1` returns a pointer to local variable `ret`.

In `main`, `ptr` points to the address of the local variable. When `ptr` is accessed in `func2`, the access is illegal because the scope of `ret` is limited to `func1`,

Result Information

Group: Static memory
Language: C | C++
Default: On
Command-Line Syntax: `LOCAL_ADDR_ESCAPE`
Impact: High
CWE ID: 562, 825

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Predefined macro used as an object

You use standard library macros such as `assert` and `errno` as objects

Description

Predefined macro used as an object occurs when you use certain identifiers in a way that requires an underlying object to be present. These identifiers are defined as macros. The C Standard does not allow you to redefine them as objects. You use the identifiers in such a way that macro expansion of the identifiers cannot occur.

For instance, you refer to an external variable `errno`:

```
extern int errno;
```

However, `errno` does not occur as a variable but a macro.

The defect applies to these macros: `assert`, `errno`, `math_errhandling`, `setjmp`, `va_arg`, `va_copy`, `va_end`, and `va_start`. The checker looks for the defect only in source files (not header files).

Risk

The C11 Standard (Sec. 7.1.4) allows you to redefine most macros as objects. To access the object and not the macro in a source file, you do one of these:

- Redeclare the identifier as an external variable or function.
- For function-like macros, enclose the identifier name in parentheses.

If you try to use these strategies for macros that cannot be redefined as objects, an error occurs.

Fix

Do not use the identifiers in such a way that a macro expansion is suppressed.

- Do not redeclare the identifiers as external variables or functions.

- For function-like macros, do not enclose the macro name in parentheses.

Examples

Use of `assert` as Function

```
#include<assert.h>
typedef void (*err_handler_func)(int);

extern void demo_handle_err(err_handler_func, int);

void func(int err_code) {
    extern void assert(int);
    demo_handle_err(&(assert), err_code);
}
```

In this example, the `assert` macro is redefined as an external function. When passed as an argument to `demo_handle_err`, the identifier `assert` is enclosed in parentheses, which suppresses use of the `assert` macro.

Correction — Use `assert` as Macro

One possible correction is to directly use the `assert` macro from `assert.h`. A different implementation of the function `demo_handle_err` directly uses the `assert` macro instead of taking the address of an `assert` function.

```
#include<assert.h>
void demo_handle_err(int err_code) {
    assert(err_code == 0);
}

void func(int err_code) {
    demo_handle_err(err_code);
}
```

Result Information

Group: Programming
Language: C | C++
Default: On

Command-Line Syntax: MACRO_USED_AS_OBJECT
Impact: Low

See Also

MISRA C:2012 Rule 21.2

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Memory leak

Memory allocated dynamically not freed

Description

Memory leak occurs when you do not free a block of memory allocated through `malloc`, `calloc`, `realloc`, or `new`. If the memory is allocated in a function, the defect does not occur if:

- Within the function, you free the memory using `free` or `delete`.
- The function returns the pointer assigned by `malloc`, `calloc`, `realloc`, or `new`.
- The function stores the pointer in a global variable or in a parameter.

Risk

Dynamic memory allocation functions such as `malloc` allocate memory on the heap. If you do not release the memory after use, you reduce the amount of memory available for another allocation. On embedded systems with limited memory, you might end up exhausting available heap memory even during program execution.

Fix

Determine the scope where the dynamically allocated memory is accessed. Free the memory block at the end of this scope.

To free a block of memory, use the `free` function on the pointer that was used during memory allocation. For instance:

```
ptr = (int*)malloc(sizeof(int));
...
free(ptr);
```

It is a good practice to allocate and free memory in the same module at the same level of abstraction. For instance, in this example, `func` allocates and frees memory at the same level but `func2` does not.

```
void func() {
  ptr = (int*)malloc(sizeof(int));
  {
    ...
  }
  free(ptr);
}

void func2() {
  {
   ptr = (int*)malloc(sizeof(int));
   ...
  }
  free(ptr);
}
```

See CERT-C Rule MEM00-C.

Examples

Dynamic Memory Not Released Before End of Function

```
#include<stdlib.h>
#include<stdio.h>

void assign_memory(void)
{
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL)
        {
         printf("Memory allocation failed");
         return;
        }


    *pi = 42;
    /* Defect: pi is not freed */
}
```

In this example, `pi` is dynamically allocated by `malloc`. The function `assign_memory` does not free the memory, nor does it return `pi`.

Correction — Free Memory

One possible correction is to free the memory referenced by `pi` using the `free` function. The `free` function must be called before the function `assign_memory` terminates

```
#include<stdlib.h>
#include<stdio.h>

void assign_memory(void)
{
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL)
        {
         printf("Memory allocation failed");
         return;
        }
    *pi = 42;

    /* Fix: Free the pointer pi*/
    free(pi);
}
```

Correction — Return Pointer from Dynamic Allocation

Another possible correction is to return the pointer `pi`. Returning `pi` allows the function calling `assign_memory` to free the memory block using `pi`.

```
#include<stdlib.h>
#include<stdio.h>

int* assign_memory(void)
{
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL)
        {
            printf("Memory allocation failed");
            return(pi);
        }
    *pi = 42;

    /* Fix: Return the pointer pi*/
    return(pi);
}
```

Memory Leak with New/Delete

```
#define NULL '\0'

void initialize_arr1(void)
{
    int *p_scalar = new int(5);
}

void initialize_arr2(void)
{
    int *p_array = new int[5];
}
```

In this example, the functions create two variables, `p_scalar` and `p_array`, using the `new` keyword. However, the functions end without cleaning up the memory for these pointers. Because the functions used `new` to create these variables, you must clean up their memory by calling `delete` at the end of each function.

Correction — Add Delete

To correct this error, add a `delete` statement for every `new` initialization. If you used brackets `[]` to instantiate a variable, you must call delete with brackets as well.

```
#define NULL '\0'

void initialize_arrs(void)
{
    int *p_scalar = new int(5);
    int *p_array = new int[5];

    delete p_scalar;
    p_scalar = NULL;

    delete[] p_array;
    p_scalar = NULL;
}
```

Check Information

Group: Dynamic memory

Language: C | C++
Default: Off
Command-Line Syntax: `MEM_LEAK`
Impact: Medium
CWE ID: 401, 404

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Invalid use of standard library memory routine

Standard library memory function called with invalid arguments

Description

Invalid use of standard library memory routine occurs when a memory library function is called with invalid arguments. For instance, the `memcpy` function copies to an array that cannot accommodate the number of bytes copied.

Risk

Use of a memory library function with invalid arguments can result in issues such as buffer overflow.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Invalid Use of Standard Library Memory Routine Error

```
#include <string.h>
#include <stdio.h>
```

```
char* Copy_First_Six_Letters(void)
 {
  char str1[10],str2[5];

  printf("Enter string:\n");
  scanf("%s",str1);

  memcpy(str2,str1,6);
  /* Defect: Arguments of memcpy invalid: str2 has size < 6 */

  return str2;
 }
```

The size of string `str2` is 5, but six characters of string `str1` are copied into `str2` using the `memcpy` function.

Correction — Call Function with Valid Arguments

One possible correction is to adjust the size of `str2` so that it accommodates the characters copied with the `memcpy` function.

```
#include <string.h>
#include <stdio.h>

char* Copy_First_Six_Letters(void)
 {
  /* Fix: Declare str2 with size 6 */
  char str1[10],str2[6];

  printf("Enter string:\n");
  scanf("%s",str1);

  memcpy(str2,str1,6);
  return str2;
 }
```

Check Information

Group: Static memory
Language: C | C++
Default: On
Command-Line Syntax: `MEM_STD_LIB`

Impact: High
CWE ID: 120, 227, 690

See Also

`Invalid use of standard library string routine`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Memory comparison of float-point values

Object representation of floating-point values can be different (same) for equal (not equal) floating-point values

Description

Memory comparison of float-point values occurs when you compare the object representation of floating-point values or the object representation of structures containing floating-point members. When you use the functions `memcmp`, `bcmp`, or `wmemcmp` to perform the bit pattern comparison, the defect is raised.

Risk

The object representation of floating-point values uses specific bit patterns to encode those values. Floating-point values that are equal, for instance `-0.0` and `0.0` in the IEC 60559 standard, can have different bit patterns in their object representation. Similarly, floating-point values that are not equal can have the same bit pattern in their object representation.

Fix

When you compare structures containing floating-point members, compare the structure members individually.

To compare two floating-point values, use the `==` or `!=` operators. If you follow a standard that discourages the use of these operators, such as MISRA®, ensure that the difference between the floating-point values is within an acceptable range.

Examples

Using `memcmp` to Compare Structures with Floating-Point Members

```
#include <string.h>
```

```
typedef struct {
    int i;
    float f;
} myStruct;

extern void initialize_Struct(myStruct *);

int func_cmp(myStruct *s1, myStruct *s2) {
/* Comparison between structures containing
* floating-point members */
    return memcmp
        ((const void *)s1, (const void *)s2, sizeof(myStruct));
}

void func(void) {
    myStruct s1, s2;
    initialize_Struct(&s1);
    initialize_Struct(&s2);
    (void)func_cmp(&s1, &s2);
}
```

In this example, `func_cmp()` calls `memcmp()` to compare the object representations of structures `s1` and `s2`. The comparison might be inaccurate because the structures contain floating-point members.

Correction — Compare Structure Members Individually

One possible correction is to compare the structure members individually and to ensure that the difference between the floating-point values is within an acceptable range defined by `ESP`.

```
 #include <string.h>

typedef struct {
    int i;
    float f;
} myStruct;

extern void initialize_Struct(myStruct *);

#define ESP 0.00001

int func_cmp(myStruct *s1, myStruct *s2) {
```

```
/*Structure members are compared individually */
    return ((s1->i == s2->i) &&
            (fabsf(s1->f - s2->f) <= ESP));
}

void func(void) {
    myStruct s1, s2;
    initialize_Struct(&s1);
    initialize_Struct(&s2);
    (void)func_cmp(&s1, &s2);
}
```

Result Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: MEMCMP_FLOAT
Impact: Low

See Also

Floating point comparison with equality operators|Memory comparison of padding data|Memory comparison of strings

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Memory comparison of padding data

`memcmp` compares data stored in structure padding

Description

Memory comparison of padding data occurs when you use the `memcmp` function to compare two structures as a whole. In the process, you compare meaningless data stored in the structure padding.

For instance:

```
struct structType {
    char member1;
    int member2;
    .
    .
};

structType var1;
structType var2;
.
.
if(memcmp(&var1,&var2,sizeof(var1)))
{...}
```

Risk

If members of a structure have different data types, your compiler introduces additional padding for data alignment in memory. For an example of padding, see `Higher Estimate of Local Variable Size`.

The content of these extra padding bytes is meaningless. The C Standard allows the content of these bytes to be indeterminate, giving different compilers latitude to implement their own padding. If you perform a byte-by-byte comparison of structures with `memcmp`, you compare even the meaningless data stored in the padding. You might reach the false conclusion that two data structures are not equal, even if their corresponding members have the same value.

Fix

Instead of comparing two structures in one attempt, compare the structures member by member.

For efficient code, write a function that does the comparison member by member. Use this function for comparing two structures.

You can use `memcmp` for byte-by-byte comparison of structures only if you know that the structures do not contain padding. Typically, to prevent padding, you use specific attributes or pragmas such as `#pragma pack`. However, these attributes or pragmas are not supported by all compilers and make your code implementation-dependent. If your structures contain bit-fields, using these attributes or pragmas cannot prevent padding.

Examples

Structures Compared with `memcmp`

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define fatal_error() abort()

typedef struct s_padding
{
    char c;
    int i;
    unsigned int bf1:1;
    unsigned int bf2:2;
    unsigned char buffer[20];
} S_Padding ;

/* Function that guarantees safe access to the input memory */
extern int trusted_memory_zone(void *ptr, size_t sz);

int func(const S_Padding *left, const S_Padding *right)
{

    if (!trusted_memory_zone((void *)left, sizeof(S_Padding)) ||
        !trusted_memory_zone((void *)right, sizeof(S_Padding))) {
```

```
        fatal_error();
    }

    if (0 == memcmp(left, right, sizeof(S_Padding)))
    {
        return 1;
    }
    else
        return 0;
}
```

In this example, `memcmp` compares byte-by-byte the two structures that `left` and `right` point to. Even if the values stored in the structure members are the same, the comparison can show an inequality if the meaningless values in the padding bytes are not the same.

Correction — Compare Structures Member by Member

One possible correction is to compare individual structure members.

Note You can compare entire arrays by using `memcmp`. All members of an array have the same data type. Padding bytes are not required to store arrays.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define fatal_error() abort()

typedef struct s_padding
{
    char c;
    int i;
    unsigned int bf1:1;
    unsigned int bf2:2;
    unsigned char buffer[20];
} S_Padding ;

/* Function that guarantees safe access to the input memory */
extern int trusted_memory_zone(void *ptr, size_t sz);

int func(const S_Padding *left, const S_Padding *right)
{
```

```
    if (!trusted_memory_zone((void *)left, sizeof(S_Padding)) ||
        !trusted_memory_zone((void *)right, sizeof(S_Padding))) {
        fatal_error();
    }

    return ((left->c == right->c) &&
            (left->i == right->i) &&
            (left->bf1 == right->bf1) &&
            (left->bf2 == right->bf2) &&
            (memcmp(left->buffer, right->buffer, 20) == 0));
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `MEMCMP_PADDING_DATA`
Impact: Medium
CWE ID: 188

See Also

`Memory comparison of strings`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Memory comparison of strings

`memcmp` compares data stored in strings after the null terminator

Description

Memory comparison of strings occurs when:

- You compare two strings byte-by-byte with the `memcmp` function.
- The number of bytes compared is such that you compare meaningless data stored after the null terminator.

For instance:

```
memcmp(string1, string2, sizeof(string1))
```

can compare bytes in the string after the null terminator.

Risk

The null terminator signifies the end of a string. Comparison of bytes after the null terminator is meaningless. You might reach the false conclusion that two strings are not equal, even if the bytes before the null terminator store the same value.

Fix

Use `strcmp` for string comparison. The function compares strings only up to the null terminator.

If you use `memcmp` for a byte-by-byte comparison of two strings, avoid comparison of bytes after the null terminator. Determine the number of bytes to compare by using the `strlen` function.

Examples

Strings Compared with `memcmp`

```
#include <stdio.h>
#include <string.h>

#define SIZE20 20

int func()
{
    char s1[SIZE20] =  "abc";
    char s2[SIZE20] =  "abc";

    return memcmp(s1, s2, sizeof(s1));
}
```

In this example, `sizeof` returns the length of the entire array `s1`, which is 20. However, only the first three bytes of the string are relevant.

Even though `s1` and `s2` hold the same value, the comparison with `memcmp` can show a false inequality.

Correction — Use `strlen` to Determine Number of Bytes to Compare

One possible correction is to determine the number of bytes to compare using the `strlen` function. `strlen` returns the number of bytes *before* the null terminator (and excluding the null terminator itself).

```
#include <stdio.h>
#include <string.h>

#define SIZE20 20

int func()
{
    char s1[SIZE20] =  "abc";
    char s2[SIZE20] =  "abc";

    return memcmp(s1, s2, strlen(s1));
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `MEMCMP_STRINGS`
Impact: Medium
CWE ID: 188

See Also

`Memory comparison of padding data`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Use of memset with size argument zero

Size argument of function in `memset` family is zero

Description

Use of memset with size argument zero occurs when you call a function in the `memset` family with size argument zero. Functions include `memset`, `wmemset`, `bzero`, `SecureZeroMemory`, `RtlSecureZeroMemory`, and so on.

Risk

`void *memset (void *ptr, int value, size_t num)` fills the first `num` bytes of the memory block that `ptr` points to with the specified `value`. A zero value of `num` renders the call to `memset` redundant. The memory that `ptr` points to:

- Remains uninitialized, if not previously initialized.
- Is not cleared and can contain sensitive data, if previously initialized.

Fix

Determine if the zero size argument occurs because of a previous error in your code. Fix the error.

Examples

Zero Size Argument of `memset`

```
#include <stdio.h>
#include <string.h>

void func (unsigned int size)
{
    char str[] = "Buffer to be filled.";
    memset (str,'-',size);
```

```
    puts (str);
}

void calling_func(void) {
    unsigned int buf_size=0;
    func(buf_size);
}
```

In this example, the argument `size` of `memset` is zero.

Result Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: `MEMSET_INVALID_SIZE`
Impact: Medium
CWE ID: 665

See Also

`Call to memset with unintended value`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Call to memset with unintended value

`memset` or `wmemset` used with possibly incorrect arguments

Description

Call to memset with unintended value occurs when Polyspace Bug Finder detects a use of the `memset` or `wmemset` function with possibly incorrect arguments.

`void *memset (void *ptr, int value, size_t num)` fills the first `num` bytes of the memory block that `ptr` points to with the specified `value`. If the argument `value` is incorrect, the memory block is initialized with an unintended value.

The unintended initialization can occur in the following cases.

Issue	Risk	Possible Fix
The second argument is `'0'` instead of `0` or `'\0'`.	The ASCII value of character `'0'` is `48` (decimal), `0x30` (hexadecimal), `069` (octal) but not `0` (or `'\0'`) .	If you want to initialize with `'0'`, use one of the ASCII values. Otherwise, use `0` or `'\0'`.
The second and third arguments are probably reversed. For instance, the third argument is a literal and the second argument is not a literal.	If the order is reversed, a memory block of unintended size is initialized with incorrect arguments.	Reverse the order of the arguments.

Issue	Risk	Possible Fix
The second argument cannot be represented in a byte.	If the second argument cannot be represented in a byte, and you expect each byte of a memory block to be filled with that argument, the initialization does not occur as intended.	Apply a bit mask to the argument to produce a wrapped or truncated result that can be represented in a byte. When you apply a bit mask, make sure that it produces an expected result. For instance, replace `memset(a, -13, sizeof(a))` with `memset(a, (-13) & 0xFF, sizeof(a))`.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Value Cannot Be Represented in a Byte

```
#include <string.h>

#define SIZE 32
void func(void) {
    char buf[SIZE];
```

```
    int c = -2;
    memset(buf, (char)c, sizeof(buf));
}
```

In this example, `(char)c` cannot be represented in a byte.

Correction — Apply Cast

One possible correction is to apply a cast so that the result can be represented in a byte. However, check that the result of the cast is an acceptable initialization value.

```
#include <string.h>

#define SIZE 32
void func(void) {
    char buf[SIZE   ];
    int c = -2;
    memset(buf, (unsigned char)c, sizeof(buf));
}
```

Result Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: `MEMSET_INVALID_VALUE`
Impact: Low
CWE ID: 665, 683

See Also

`Use of memset with size argument zero`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Base class assignment operator not called

Copy assignment operator does not call copy assignment operators of base subobjects

Description

Base class assignment operator not called occurs when a derived class copy assignment operator does not call the copy assignment operator of its base class.

Risk

If this defect occurs, unless you are initializing the base class data members explicitly in the derived class assignment operator, the operator initializes the members implicitly by using the default constructor of the base class. Therefore, it is possible that the base class data members do not get assigned the right values.

If users of your class expect your assignment operator to perform a complete assignment between two objects, they can face unintended consequences.

Fix

Call the base class copy assignment operator from the derived class copy assignment operator.

Even if the base class data members are not `private`, and you explicitly initialize the base class data members in the derived class copy assignment operator, replace this explicit initialization with a call to the base class copy assignment operator. Otherwise, determine why you retain the explicit initialization.

Examples

Base Class Copy Assignment Operator Not Called

```
class Base0 {
public:
```

```
    Base0();
    virtual ~Base0();
    Base0& operator=(const Base0&);
private:
    int _i;
};

class Base1 {
public:
    Base1();
    virtual ~Base1();
    Base1& operator=(const Base1&);
private:
    int _i;
};

class Derived: public Base0, Base1 {
public:
    Derived();
    ~Derived();
    Derived& operator=(const Derived& d) {
        if (&d == this) return *this;
        Base0::operator=(d);
        _j = d._j;
        return *this;
    }
private:
    int _j;
};
```

In this example, the class `Derived` is derived from two classes `Base0` and `Base1`. In the copy assignment operator of `Derived`, only the copy assignment operator of `Base0` is called. The copy assignment operator of `Base1` is not called.

The defect appears on the copy assignment operator of the derived class. Following are some tips for navigating in the source code:

- To find the derived class definition, right-click the derived class name and select **Go To Definition**.
- To find the base class definition, first navigate to the derived class definition. In the derived class definition, right-click the base class name and select **Go To Definition**.

- To find the definition of the base class copy assignment operator, first navigate to the base class definition. In the base class definition, right-click the operator name and select **Go To Definition**.

Correction — Call Base Class Copy Assignment Operator

If you want your copy assignment operator to perform a complete assignment, one possible correction is to call the copy assignment operator of class `Base1`.

```
class Base0 {
public:
    Base0();
    virtual ~Base0();
    Base0& operator=(const Base0&);
private:
    int _i;
};

class Base1 {
public:
    Base1();
    virtual ~Base1();
    Base1& operator=(const Base1&);
private:
    int _i;
};

class Derived: public Base0, Base1 {
public:
    Derived();
    ~Derived();
    Derived& operator=(const Derived& d) {
        if (&d == this) return *this;
        Base0::operator=(d);
        Base1::operator=(d);
        _j = d._j;
        return *this;
    }
private:
    int _j;
};
```

Result Information

Group: Object oriented
Language: C++
Default: On
Command-Line Syntax: `MISSING_BASE_ASSIGN_OP_CALL`
Impact: High

See Also

`Copy constructor not called in initialization list`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Missing byte reordering when transferring data

Different endianness of host and network

Description

Missing byte reordering when transferring data occurs when you do not use a byte ordering function:

- Before sending data to a network socket.
- After receiving data from a network socket.

Risk

Some system architectures implement little endian byte ordering (least significant byte first), and other systems implement big endian (most significant byte first). If the endianness of the sent data does not match the endianness of the receiving system, the value returned when reading the data is incorrect.

Fix

After receiving data from a socket, use a byte ordering function such as `ntohl()`. Before sending data to a socket, use a byte ordering function such as `htonl()` .

Examples

Data Transferred Without Byte Reordering

```
#include <stdio.h>
#include <stdlib.h>
#include <stdint.h>
#include <sys/types.h>
#include <sys/socket.h>
```

```
#include <arpa/inet.h>
#include <byteswap.h>
#include <unistd.h>
#include <string.h>


unsigned int func(int sock, int server)
{
    unsigned int num;   /* assume int is 32-bits */
    if (server)
    {
        /* Server side */
        num = 0x17;
        /* Endianness of server host may not match endianness of network. */
        if (send(sock, (void *)&num, sizeof(num), 0) < (int)sizeof(num))
        {
            /* Handle error */
        }
        return 0;
    }
    else {
        /* Endianness of client host may not match endianness of network. */
        if (recv (sock, (void *)&num, sizeof(num), 0) < (int) sizeof(num))
        {
            /* Handle error */
        }

        /* Comparison may be inaccurate */
        if (num> 255)
        {
            return 255;
        }
        else
        {
            return num;
        }
    }
}
```

In this example, variable `num` is assigned hexadecimal value `0x17` and is sent over a network to the client from the server. If the server host is little endian and the network is

big endian, `num` is transferred as `0x17000000`. The client then reads an incorrect value for `num` and compares it to a local numeric value.

Correction — Use Byte Ordering Function

Before sending `num` from the server host, use `htonl()` to convert from host to network byte ordering. Similarly, before reading `num` on the client host, use `ntohl()` to convert from network to host byte ordering.

```
#include <stdio.h>
#include <stdlib.h>
#include <stdint.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <arpa/inet.h>
#include <byteswap.h>
#include <unistd.h>
#include <string.h>

unsigned int func(int sock, int server)
{
    unsigned int num;   /* assume int is 32-bits */
    if (server)
    {
        /* Server side */
        num = 0x17;

        /* Convert to network byte order. */
        num = htonl(num);
        if (send(sock, (void *)&num, sizeof(num), 0) < (int)sizeof(num))
        {
            /* Handle error */
        }
        return 0;
    }
    else {
        if (recv (sock, (void *)&num, sizeof(num), 0) < (int) sizeof(num))
        {
            /* Handle error */
        }

        /* Convert to host byte order. */
        num = ntohl(num);
        if (num > 255)
```

```
        {
            return 255;
        }
        else
        {
            return num;
        }
    }
}
```

Result Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: `MISSING_BYTESWAP`
Impact: Medium
CWE ID: 188, 198

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Copy constructor not called in initialization list

Copy constructor does not call copy constructors of some members or base classes

Description

Copy constructor not called in initialization list occurs when the copy constructor of a class does not call the *copy constructor* of the following in its initialization list:

- One or more of its members.
- Its base classes when applicable.

  The defect occurs even when a base class constructor is called instead of the base class copy constructor.

Risk

The calls to the copy constructors can be done only from the initialization list. If the calls are missing, it is possible that an object is only partially copied.

- If the copy constructor of a member is not called, it is possible that the member is not copied.
- If the copy constructor of a base class is not called, it is possible that the base class members are not copied.

Fix

If you want your copy constructor to perform a complete copy, call the copy constructor of all members and all base classes in its initialization list.

Examples

Base Class Copy Constructor Not Called

```
class Base {
public:
    Base();
    Base(int);
    Base(const Base&);
    virtual ~Base();
private:
    int ib;
};

class Derived:public Base {
public:
    Derived();
    ~Derived();
    Derived(const Derived& d): Base(), i(d.i) { }
private:
    int i;
};
```

In this example, the copy constructor of class `Derived` calls the default constructor, but not the copy constructor of class `Base`.

The defect appears on the `:` symbol in the copy constructor definition. Following are some tips for navigating in the source code:

- To navigate to the class definition, right-click a member that is initialized in the constructor. Select **Go To Definition**. In the class definition, you see the class members, including those members whose copy constructors are not called.
- To navigate to a base class definition, first navigate to the derived class definition. In the derived class definition, where the derived class inherits from a base class, right-click the base class name and select **Go To Definition**.

Correction — Call Base Class Copy Constructor

One possible correction is to call the copy constructor of class `Base` from the initialization list of the `Derived` class copy constructor.

```
class Base {
public:
```

```
    Base();
    Base(int);
    Base(const Base&);
    virtual ~Base();
private:
    int ib;
};

class Derived:public Base {
public:
    Derived();
    ~Derived();
    Derived(const Derived& d): Base(d), i(d.i) { }
private:
    int i;
};
```

Result Information

Group: Object oriented
Language: C++
Default: On
Command-Line Syntax: `MISSING_COPY_CTOR_CALL`
Impact: High

See Also

`Base class assignment operator not called`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Errno not reset

`errno` not reset before calling a function that sets `errno`

Description

Errno not reset occurs when you do not reset `errno` before calling a function that sets `errno` to indicate error conditions. However, you check `errno` for those error conditions after the function call.

Risk

The `errno` is not clean and can contain values from a previous call. Checking `errno` for errors can give the false impression that an error occurred.

`errno` is set to zero at program startup but subsequently, `errno` is not reset by a C standard library function. You must explicitly set `errno` to zero when required.

Fix

Before calling a function that sets `errno` to indicate error conditions, reset `errno` to zero explicitly.

Examples

`errno` Not Reset Before Call to `strtod`

```
#include <stdio.h>
#include <stdlib.h>
#include <errno.h>
#include <float.h>

#define fatal_error() abort()

double func(const char *s1, const char *s2)
{
```

```
    double f1;
    f1 = strtod (s1, NULL);
    if (0 == errno) {
      double f2 = strtod (s2, NULL);
        if (0 == errno) {
            long double result = (long double)f1 + f2;
            if ((result <= (long double)DBL_MAX) && (result >= (long double)-DBL_MAX))
                  {
                return (double)result;
            }
        }
    }
    fatal_error();
    return 0.0;
}
```

In this example, `errno` is not reset to 0 before the first call to `strtod`. Checking `errno` for 0 later can lead to a false positive.

Correction — Reset `errno` Before Call

One possible correction is to reset `errno` to 0 before calling `strtod`.

```
#include <stdio.h>
#include <stdlib.h>
#include <errno.h>
#include <float.h>

#define fatal_error() abort()

double func(const char *s1, const char *s2)
{
    double f1;
    errno = 0;
    f1 = strtod (s1, NULL);
    if (0 == errno) {
      double f2 = strtod (s2, NULL);
        if (0 == errno) {
            long double result = (long double)f1 + f2;
            if ((result <= (long double)DBL_MAX) && (result >= (long double)-DBL_MAX))
              {
                return (double)result;
            }
        }
    }
```

```
    fatal_error();
    return 0.0;
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `MISSING_ERRNO_RESET`
Impact: High
CWE ID: 253, 456, 703

See Also

`Errno not checked` | `Errno not reset` | `Returned value of a sensitive function not checked`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Missing explicit keyword

Constructor missing the `explicit` specifier

Description

Missing `explicit` keyword occurs when the declaration of a constructor does not use the `explicit` specifier. The `explicit` specifier prevents implicit conversion from a variable of another type to the current class type.

The defect applies to:

- One-parameter constructors.
- Constructors where all but one parameters have default values.

  For instance, `MyClass::MyClass(float f, bool b=true){}`.

Risk

If you do not declare a constructor `explicit`, compilers can perform unexpected and often unintended type conversions to the class type using the constructor.

The implicit conversion can occur, for instance, when a function accepts a parameter of the class type, but you call the function with an argument of a different type.

Fix

For better readability of your code and to prevent implicit conversions, in the constructor declaration, place the `explicit` keyword before the constructor name.

If you want to convert from a variable of another type, explicitly call the class constructor and pass the variable as argument.

Examples

Missing `explicit` Keyword

```
class MyClass {
public:
    MyClass(int val);
private:
    int val;
};

void func(MyClass);

void main() {
    MyClass MyClassObject(0);

    func(MyClassObject);   // No conversion
    func(MyClass(0));      // Explicit conversion
    func(0);               // Implicit conversion
}
```

In this example, the constructor of `MyClass` is not declared `explicit`. Therefore, the call `func(0)` can perform an implicit conversion from `int` to `MyClass`.

Correction — Use `explicit` Keyword

One possible correction is to declare the constructor of `MyClass` as `explicit`. If an operation in your code performs an implicit conversion, the compiler generates an error. Therefore, using the `explicit` keyword, you detect unintended type conversions in the compilation stage.

For instance, in function `main` below, if you add the statement `func(0);` that performs implicit conversion, the code does not compile.

```
class MyClass {
public:
    explicit MyClass(int val);
private:
    int val;
};

void func(MyClass);
```

```
void main() {
    MyClass MyClassObject(0);

    func(MyClassObject);   // No conversion
    func(MyClass(0));      // Explicit conversion
}
```

Incorrect Argument Order Preventable Through `explicit` Keyword

```
class Month {
    int val;
public:
    Month(int m): val(m) {}
    ~Month() {}
};

class Day {
    int val;
public:
    Day(int d): val(d) {}
    ~Day() {}
};

class Year {
    int val;
public:
    Year(int y): val(y) {}
    ~Year() {}
};

class Date {
    Month mm;
    Day dd;
    Year yyyy;
public:
    Date(const Month & m, const Day & d, const Year & y):mm(m), dd(d), yyyy(y) {}
};

void main() {
    Date(20,1,2000); //Implicit conversion, wrong argument order undetected
}
```

In this example, the constructors for classes `Month`, `Day` and `Year` do not have an `explicit` keyword. They allow implicit conversion from `int` variables to `Month`, `Day` and `Year` variables.

When you create a `Date` variable and use an incorrect argument order for the `Date` constructor, because of the implicit conversion, your code compiles. You might not detect that you have switched the month value and the day value.

Correction — Use `explicit` Keyword

If you use the `explicit` keyword for the constructors of classes `Month`, `Day` and `Year`, you cannot call the `Date` constructor with an incorrect argument order.

- If you call the `Date` constructor with `int` variables, your code does not compile because the `explicit` keyword prevents implicit conversion from `int` variables.
- If you call the `Date` constructor with the arguments explicitly converted to `Month`, `Day` and `Year`, and have the wrong argument order, your code does not compile because of the argument type mismatch.

```
class Month {
    int val;
public:
    explicit Month(int m): val(m) {}
    ~Month() {}
};

class Day {
    int val;
public:
    explicit Day(int d): val(d) {}
    ~Day() {}
};

class Year {
    int val;
public:
    explicit Year(int y): val(y) {}
    ~Year() {}
};

class Date {
    Month mm;
    Day dd;
```

```
    Year yyyy;
public:
    Date(const Month & m, const Day & d, const Year & y):mm(m), dd(d), yyyy(y) {}
};

void main() {
    Date(Month(1),Day(20),Year(2000));
    // Date(20,1,2000); - Does not compile
    // Date(Day(20), Month(1), Year(2000)); - Does not compile
}
```

Result Information

Group: Object oriented
Language: C++
Default: Off
Command-Line Syntax: MISSING_EXPLICIT_KEYWORD
Impact: Low

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Missing reset of a freed pointer

Pointer `free` not followed by a reset statement to clear leftover data

Description

Missing reset of a freed pointer detects pointers that have been freed and not reassigned another value. After freeing a pointer, the memory data is still accessible. To clear this data, the pointer must also be set to NULL or another value.

Risk

Not resetting pointers can cause dangling pointers. Dangling pointers can cause:

- Freeing already freed memory.
- Reading from or writing to already freed memory.
- Hackers executing code stored in freed pointers or with vulnerable permissions.

Fix

After freeing a pointer, if it is not immediately assigned to another valid address, set the pointer to NULL.

Examples

Free Without Reset

```
#include <stdlib.h>
enum {
    SIZE3   = 3,
    SIZE20  = 20
};

void missingfreedptrreset()
{
```

```
    static char *str = NULL;

    if (str == NULL)
        str = (char *)malloc(SIZE20);

    if (str != NULL)
        free(str);
}
```

In this example, the pointer `str` is freed at the end of the program. The next call to `bug_missingfreedptrrese` can fail because `str` is not NULL and the initialization to NULL can be invalid.

Correction — Redefine `free` to Free and Reset

One possible correction is to customize `free` so that when you free a pointer, it is automatically reset.

```
#include <stdlib.h>
enum {
    SIZE3   = 3,
    SIZE20  = 20
};

static void sanitize_free(void **p)
{
    if ((p != NULL) && (*p != NULL))
    {
        free(*p);
        *p = NULL;
    }
}

#define free(X) sanitize_free((void **)&X)

void missingfreedptrreset()
{
    static char *str = NULL;

    if (str == NULL)
        str = (char *)malloc(SIZE20);

    if (str != ((void *)0))
    {
```

```
        free(str);
    }
}
```

Result Information

Group: Good Practice
Language: C | C++
Default: Off
Command-Line Syntax: `MISSING_FREED_PTR_RESET`
Impact: Low
CWE ID: 415, 416, 825

See Also

`Use of previously freed pointer` | `Invalid free of pointer`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2016b

Missing null in string array

String does not terminate with null character

Description

Missing null in string array occurs when a string does not have enough space to terminate with a null character `'\0'`.

This defect applies only for projects in C.

Risk

A buffer overflow can occur if you copy a string to an array without assuming the implicit null terminator.

Fix

If you initialize a character array with a literal, avoid specifying the array bounds.

```
char three[]  = "THREE";
```

The compiler automatically allocates space for a null terminator. In the preceding example, the compiler allocates sufficient space for five characters and a null terminator.

If the issue occurs after initialization, you might have to increase the size of the array by one to account for the null terminator.

In certain circumstances, you might want to initialize the character array with a sequence of characters instead of a string. In this situation, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Array size is too small

```
void countdown(int i)
{
    static char one[5]   = "ONE";
    static char two[5]   = "TWO";
    static char three[5] = "THREE";
}
```

The character array `three` has a size of 5 and 5 characters `'T'`, `'H'`, `'R'`, `'E'`, and `'E'`. There is no room for the null character at the end because `three` is only five bytes large.

Correction — Increase Array Size

One possible correction is to change the array size to allow for the five characters plus a null character.

```
void countdown(int i)
{
    static char one[5]   = "ONE";
    static char two[5]   = "TWO";
    static char three[6] = "THREE";
}
```

Correction — Change Initialization Method

One possible correction is to initialize the string by leaving the array size blank. This initialization method allocates enough memory for the five characters and a terminating-null character.

```
void countdown(int i)
{
    static char one[5]   = "ONE";
    static char two[5]   = "TWO";
    static char three[]  = "THREE";
}
```

Check Information

Group: Programming
Language: C
Default: On for handwritten code, off for generated code
Command-Line Syntax: `MISSING_NULL_CHAR`
Impact: Low
CWE ID: 170

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Missing overload of allocation or deallocation function

Only one function in an allocation-deallocation function pair is overloaded

Description

Missing overload of allocation or deallocation function occurs when you overload `operator new` but do not overload the corresponding `operator delete`, or vice versa.

Risk

You typically overload `operator new` to perform some bookkeeping in addition to allocating memory on the free store. Unless you overload the corresponding `operator delete`, it is likely that you omitted some corresponding bookkeeping when deallocating the memory.

The defect can also indicate a coding error. For instance, you overloaded the placement form of `operator new[]`:

```
void *operator new[](std::size_t count, void *ptr);
```

but the non-placement form of `operator delete[]`:

```
void operator delete[](void *ptr);
```

instead of the placement form:

```
void operator delete[](void *ptr, void *p );
```

Fix

When overloading `operator new`, make sure that you overload the corresponding `operator delete` in the same scope, and vice versa.

For instance, in a class, if you overload the placement form of `operator new`:

```
class MyClass {
   void* operator new  ( std::size_t count, void* ptr ){
```

```
   ...
   }
};
```

Make sure that you also overload the placement form of `operator delete`:

```
class MyClass {
   void operator delete  ( void* ptr, void* place ){
   ...
   }
};
```

To find the `operator delete` corresponding to an `operator new`, see the reference pages for `operator new` and `operator delete`.

Examples

Mismatch Between Overloaded `operator new` and `operator delete`

```
#include <new>
#include <cstdlib>

int global_store;

void update_bookkeeping(void *allocated_ptr, bool alloc) {
   if(alloc)
      global_store++;
   else
      global_store--;
}


void *operator new(std::size_t size, const std::nothrow_t& tag);
void *operator new(std::size_t size, const std::nothrow_t& tag) {
    void *ptr = (void*)malloc(size);
    if (ptr != nullptr)
        update_bookkeeping(ptr, true);
    return ptr;
}

void operator delete[](void *ptr, const std::nothrow_t& tag);
```

```
void operator delete[](void* ptr, const std::nothrow_t& tag) {
    update_bookkeeping(ptr, false);
    free(ptr);
}
```

In this example, the operators `operator new` and `operator delete[]` are overloaded but there are no overloads of the corresponding `operator delete` and `operator new[]` operators.

The overload of `operator new` calls a function `update_bookkeeping` to change the value of a global variable `global_store`. If the default `operator delete` is called, this global variable is unaffected, which might defy developer's expectations.

Correction — Overload the Correct Form of `operator delete`

If you want to overload `operator new`, overload the corresponding form of `operator delete` in the same scope.

```
#include <new>
#include <cstdlib>

int global_store;

void update_bookkeeping(void *allocated_ptr, bool alloc) {
   if(alloc)
      global_store++;
   else
      global_store--;
}


void *operator new(std::size_t size, const std::nothrow_t& tag);
void *operator new(std::size_t size, const std::nothrow_t& tag) {
    void *ptr = (void*)malloc(size);
    if (ptr != nullptr)
        update_bookkeeping(ptr, true);
    return ptr;
}

void operator delete(void *ptr, const std::nothrow_t& tag);
void operator delete(void* ptr, const std::nothrow_t& tag) {
    update_bookkeeping(ptr, false);
    free(ptr);
}
```

Result Information

Group: Good practice
Language: C++
Default: Off
Command-Line Syntax: `MISSING_OVERLOAD_NEW_DELETE_PAIR`
Impact: Low

See Also

`Invalid deletion of pointer` | `Invalid free of pointer` | `Memory leak` | `Mismatched alloc/dealloc functions on Windows`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2019a

Privilege drop not verified

Attacker can gain unintended elevated access to program

Description

Privilege drop not verified detects calls to functions that relinquish privileges. If you do not verify that the privileges were dropped before the end of your function, a defect is raised.

Risk

If privilege relinquishment fails, an attacker can regain elevated privileges and have more access to your program than intended. This security hole can cause unexpected behavior in your code if left open.

Fix

Before the end of scope, verify that the privileges that you dropped were actually dropped.

Examples

Drop Privileges Within a Function

```
#define _BSD_SOURCE
#include <sys/types.h>
#include <unistd.h>
#include <grp.h>
#include <stdlib.h>
#define fatal_error() abort()
extern int need_more_privileges;

void missingprivilegedropcheck()
{
    /* Code intended to run with elevated privileges */
```

```
    /* Temporarily drop elevated privileges */
    if (seteuid(getuid()) != 0) {
        /* Handle error */
        fatal_error();
    }

    /* Code intended to run with lower privileges */

    if (need_more_privileges) {
        /* Restore elevated privileges */
        if (seteuid(0) != 0) {
            /* Handle error */
            fatal_error();
        }
        /* Code intended to run with elevated privileges */
    }

    /* ... */

    /* Permanently drop elevated privileges */
    if (setuid(getuid()) != 0) {
        /* Handle error */
        fatal_error();
    }

    /* Code intended to run with lower privileges */
}
```

In this example, privileges are elevated and dropped to run code with the intended privilege level. When privileges are dropped, the privilege level before exiting the function body is not verified. A malicious attacker can regain their elevated privileges.

Correction — Verify Privilege Drop

One possible correction is to use `setuid` to verify that the privileges were dropped.

```
#define _BSD_SOURCE
#include <sys/types.h>
#include <unistd.h>
#include <grp.h>
#include <stdlib.h>
#define fatal_error() abort()
extern int need_more_privileges;
```

```
void missingprivilegedropcheck()
{
    /* Store the privileged ID for later verification */
    uid_t privid = geteuid();

    /* Code intended to run with elevated privileges   */

    /* Temporarily drop elevated privileges */
    if (seteuid(getuid()) != 0) {
        /* Handle error */
        fatal_error();
    }

    /* Code intended to run with lower privileges  */

    if (need_more_privileges) {
        /* Restore elevated Privileges */
        if (seteuid(privid) != 0) {
            /* Handle error */
            fatal_error();
        }
        /* Code intended to run with elevated privileges   */
    }

    /* ... */

    /* Restore privileges if needed */
    if (geteuid() != privid) {
        if (seteuid(privid) != 0) {
            /* Handle error */
            fatal_error();
        }
    }

    /* Permanently drop privileges */
    if (setuid(getuid()) != 0) {
        /* Handle error */
        fatal_error();
    }

    if (setuid(0) != -1) {
        /* Privileges can be restored, handle error */
        fatal_error();
    }
```

```
    /* Code intended to run with lower privileges; */
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `MISSING_PRIVILEGE_DROP_CHECK`
Impact: High
CWE ID: 250, 273

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2016b

Missing return statement

Function does not return value though return type is not `void`

Description

Missing return statement occurs when a function does not return a value along at least one execution path. If the return type of the function is `void`, this error does not occur.

Risk

If a function has a non-`void` return value in its signature, it is expected to return a value. The return value of this function can be used in later computations. If the execution of the function body goes through a path where a `return` statement is missing, the function return value is indeterminate. Computations with this return value can lead to unpredictable results.

Fix

In most cases, you can fix this defect by placing the `return` statement at the end of the function body.

Alternatively, you can identify which execution paths through the function body do not have a `return` statement and add a `return` statement on those paths. Often the result details show a sequence of events that indicate this execution path. You can add a `return` statement at an appropriate point in the path. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Missing or invalid return statement error

```
int AddSquares(int n)
 {
   int i=0;
   int sum=0;

   if(n!=0)
    {
     for(i=1;i<=n;i++)
        {
         sum+=i^2;
        }
     return(sum);
    }
 }
/* Defect: No return value if n is not 0*/
```

If `n` is equal to 0, the code does not enter the `if` statement. Therefore, the function `AddSquares` does not return a value if `n` is 0.

Correction — Place Return Statement on Every Execution Path

One possible correction is to return a value in every branch of the `if...else` statement.

```
 int AddSquares(int n)
 {
   int i=0;
   int sum=0;

   if(n!=0)
    {
     for(i=1;i<=n;i++)
        {
         sum+=i^2;
        }
     return(sum);
    }

   /*Fix: Place a return statement on branches of if-else */
   else
```

```
    return 0;
}
```

Check Information

Group: Data flow
Language: C | C++
Default: On
Command-Line Syntax: `MISSING_RETURN`
Impact: Low

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Self assignment not tested in operator

Copy assignment operator does not test for self-assignment

Description

Self assignment not tested in operator occurs when you do not test if the argument to the copy assignment operator of an object is the object itself.

Risk

Self-assignment causes unnecessary copying. Though it is unlikely that you assign an object to itself, because of aliasing, you or users of your class cannot always detect a self-assignment.

Self-assignment can cause subtle errors if a data member is a pointer and you allocate memory dynamically to the pointer. In your copy assignment operator, you typically perform these steps:

1. Deallocate the memory originally associated with the pointer.

   ```
   delete ptr;
   ```

2. Allocate new memory to the pointer. Initialize the new memory location with contents obtained from the operator argument.

   ```
   ptr = new ptrType(*(opArgument.ptr));
   ```

If the argument to the operator, `opArgument`, is the object itself, after your first step, the pointer data member in the operator argument, `opArgument.ptr`, is not associated with a memory location. `*opArgument.ptr` contains unpredictable values. Therefore, in the second step, you initialize the new memory location with unpredictable values.

Fix

Test for self-assignment in the copy assignment operator of your class. Only after the test, perform the assignments in the copy assignment operator.

Examples

Missing Test for Self-Assignment

```
class MyClass1 { };
class MyClass2 {
public:
    MyClass2()                : p_(new MyClass1())      { }
    MyClass2(const MyClass2& f)   : p_(new MyClass1(*f.p_)) { }
    ~MyClass2()               {
        delete p_;
    }
    MyClass2& operator= (const MyClass2& f)
    {
        delete p_;
        p_ = new MyClass1(*f.p_);
        return *this;
    }
private:
    MyClass1* p_;
};
```

In this example, the copy assignment operator in `MyClass2` does not test for self-assignment. If the parameter `f` is the current object, after the statement `delete p_`, the memory allocated to pointer `f.p_` is also deallocated. Therefore, the statement `p_ = new MyClass1(*f.p_)` initializes the memory location that `p_` points to with unpredictable values.

Correction — Test for Self-Assignment

One possible correction is to test for self-assignment in the copy assignment operator.

```
class MyClass1 { };
class MyClass2 {
public:
    MyClass2()                : p_(new MyClass1())      { }
    MyClass2(const MyClass2& f)   : p_(new MyClass1(*f.p_)) { }
    ~MyClass2()               {
        delete p_;
    }
    MyClass2& operator= (const MyClass2& f)
    {
        if(&f != this) {
```

```
            delete p_;
            p_ = new MyClass1(*f.p_);
        }
        return *this;
    }
private:
    MyClass1* p_;
};
```

Result Information

Group: Object oriented
Language: C++
Default: Off
Command-Line Syntax: `MISSING_SELF_ASSIGN_TEST`
Impact: Medium

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Missing break of switch case

No comments at the end of switch case without a break statement

Description

Missing break of switch case looks for switch cases that do not end in a `break` statement. If the case does not have a code comment after it, Polyspace assumes the missing break is not intentional and raises a defect.

Risk

Switch cases without break statements fall through to the next switch case. If this fall-through is not intended, the switch case can unintentionally execute code and end the switch with unexpected results.

Fix

If you do not want a break for the highlighted switch case, add a comment to your code to document why this case falls through to the next case. This comment removes the defect from your results and makes your code more maintainable.

If you forgot the break, add it before the end of the switch case.

Examples

Switch Without Break Statements

```
enum WidgetEnum { WE_W, WE_X, WE_Y, WE_Z } widget_type;

extern void demo_do_something_for_WE_W(void);
extern void demo_do_something_for_WE_X(void);
extern void demo_report_error(void);

void bug_missingswitchbreak(enum WidgetEnum wt)
{
```

```
    /*
      In this non-compliant code example, the case where widget_type is WE_W lacks a
      break statement. Consequently, statements that should be executed only when
      widget_type is WE_X are executed even when widget_type is WE_W.
    */
    switch (wt)
    {
      case WE_W:
        demo_do_something_for_WE_W();
      case WE_X:
        demo_do_something_for_WE_X();
      default:
        /* Handle error condition */
        demo_report_error();
    }
}
```

In this example, there are two cases without `break` statements. When `wt` is `WE_W`, the statements for `WE_W`, `WE_X`, and the `default` case execute because the program falls through the two cases without a break. No defect is raised on the `default` case or last case because it does not need a break statement.

Correction — Add a Comment or `break`

To fix this example, either add a comment to mark and document the acceptable fall-through or add a break statement to avoid fall-through. In this example, case `WE_W` is supposed to fall through, so a comment is added to explicitly state this action. For the second case, a break statement is added to avoid falling through to the `default` case.

```
enum WidgetEnum { WE_W, WE_X, WE_Y, WE_Z } widget_type;

extern void demo_do_something_for_WE_W(void);
extern void demo_do_something_for_WE_X(void);
extern void demo_report_error(void);

void corrected_missingswitchbreak(enum WidgetEnum wt)
{
    switch (wt)
    {
      case WE_W:
        demo_do_something_for_WE_W();
        /* fall through to WE_X*/
      case WE_X:
        demo_do_something_for_WE_X();
```

```
        break;
      default:
        /* Handle error condition */
        demo_report_error();
    }
}
```

Result Information

Group: Good Practice
Language: C | C++
Default: Off
Command-Line Syntax: `MISSING_SWITCH_BREAK`
Impact: Low
CWE ID: 484

See Also

`Missing case for switch condition`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2016b

Missing case for switch condition

`switch` variable not covered by cases and default case is missing

Description

Missing case for switch condition occurs when the `switch` variable can take values that are not covered by a `case` statement.

Note Bug Finder only raises a defect if the switch variable is not full range.

Risk

If the `switch` variable takes a value that is not covered by a `case` statement, your program can have unintended behavior.

A switch-statement that makes a security decision is particularly vulnerable when all possible values are not explicitly handled. An attacker can use this situation to deviate the normal execution flow.

Fix

It is good practice to use a `default` statement as a catch-all for values that are not covered by a `case` statement. Even if the `switch` variable takes an unintended value, the resulting behavior can be anticipated.

Examples

Missing Default Condition

```
#include <stdio.h>
#include <string.h>

typedef enum E
```

```
{
    ADMIN=1,
    GUEST,
    UNKNOWN = 0
} LOGIN;

static LOGIN system_access(const char *username) {
  LOGIN user = UNKNOWN;

  if ( strcmp(username, "root") == 0 )
    user = ADMIN;

  if ( strcmp(username, "friend") == 0 )
    user = GUEST;

  return user;
}

int identify_bad_user(const char * username)
{
    int r=0;

    switch( system_access(username) )
    {
    case ADMIN:
        r = 1;
        break;
    case GUEST:
        r = 2;
    }

    printf("Welcome!\n");
    return r;
}
```

In this example, the `enum` parameter `User` can take a value `UNKNOWN` that is not covered by a `case` statement.

Correction — Add a Default Condition

One possible correction is to add a default condition for possible values that are not covered by a `case` statement.

```
#include <stdio.h>
#include <string.h>
```

```
typedef enum E
{
    ADMIN=1,
    GUEST,
    UNKNOWN = 0
} LOGIN;

static LOGIN system_access(const char *username) {
  LOGIN user = UNKNOWN;

  if ( strcmp(username, "root") == 0 )
    user = ADMIN;

  if ( strcmp(username, "friend") == 0 )
    user = GUEST;

  return user;
}

int identify_bad_user(const char * username)
{
    int r=0;

    switch( system_access(username) )
    {
    case ADMIN:
        r = 1;
        break;
    case GUEST:
        r = 2;
    break;
    default:
        printf("Invalid login credentials!\n");
    }

    printf("Welcome!\n");
    return r;
}
```

Result Information

Group: Security

Language: C | C++
Default: Off
Command-Line Syntax: `MISSING_SWITCH_CASE`
Impact: Low
CWE ID: 478

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Missing virtual inheritance

A base class is inherited virtually and nonvirtually in the same hierarchy

Description

Missing virtual inheritance occurs when:

- A class is derived from multiple base classes, and some of those base classes are themselves derived from a common base class.

  For instance, a class `Final` is derived from two classes, `Intermediate_left` and `Intermediate_right`. Both `Intermediate_left` and `Intermediate_right` are derived from a common class, `Base`.
- At least one of the inheritances from the common base class is `virtual` and at least one is not `virtual`.

  For instance, the inheritance of `Intermediate_right` from `Base` is `virtual`. The inheritance of `Intermediate_left` from `Base` is not `virtual`.

Risk

If this defect appears, multiple copies of the base class data members appear in the final derived class object. To access the correct copy of the base class data member, you have to qualify the member and method name appropriately in the final derived class. The development is error-prone.

For instance, when the defect occurs, two copies of the base class data members appear in an object of class `Final`. If you do not qualify method names appropriately in the class `Final`, you can assign a value to a `Base` data member but not retrieve the same value.

- You assign the value using a `Base` method accessed through `Intermediate_left`. Therefore, you assign the value to one copy of the `Base` member.
- You retrieve the value using a `Base` method accessed through `Intermediate_right`. Therefore, you retrieve a different copy of the `Base` member.

Fix

Declare all the intermediate inheritances as `virtual` when a class is derived from multiple base classes that are themselves derived from a common base class.

If you indeed want multiple copies of the `Base` data members as represented in the intermediate derived classes, use aggregation instead of inheritance. For instance, declare two objects of class `Intermediate_left` and `Intermediate_right` in the `Final` class.

Examples

Missing Virtual Inheritance

```
#include <stdio.h>
class Base {
public:
    explicit Base(int i): m_b(i) {};
    virtual ~Base() {};
    virtual int get() const {
        return m_b;
    }
    virtual void set(int b) {
        m_b = b;
    }
private:
    int m_b;
};

class Intermediate_left: virtual public Base {
public:
    Intermediate_left():Base(0), m_d1(0) {};
private:
    int m_d1;
};

class Intermediate_right: public Base {
public:
    Intermediate_right():Base(0), m_d2(0) {};
private:
    int m_d2;
```

```
};

class Final: public Intermediate_left, Intermediate_right {
public:
    Final(): Base(0), Intermediate_left(), Intermediate_right() {};
    int get() const {
        return Intermediate_left::get();
    }
    void set(int b) {
        Intermediate_right::set(b);
    }
    int get2() const {
        return Intermediate_right::get();
    }
};

int main(int argc, char* argv[]) {
    Final d;
    int val = 12;
    d.set(val);
    int res = d.get();
    printf("d.get=%d\n",res);             // Result: d.get=0
    printf("d.get2=%d\n",d.get2());       // Result: d.get2=12
    return res;
}
```

In this example, `Final` is derived from both `Intermediate_left` and `Intermediate_right`. `Intermediate_left` is derived from `Base` in a non-`virtual` manner and `Intermediate_right` is derived from `Base` in a `virtual` manner. Therefore, two copies of the base class and the data member `m_b` are present in the final derived class,

Both derived classes `Intermediate_left` and `Intermediate_right` do not override the `Base` class methods `get` and `set`. However, `Final` overrides both methods. In the overridden `get` method, it calls `Base::get` through `Intermediate_left`. In the overridden `set` method, it calls `Base::set` through `Intermediate_right`.

Following the statement `d.set(val)`, `Intermediate_right`'s copy of `m_b` is set to 12. However, `Intermediate_left`'s copy of `m_b` is still zero. Therefore, when you call `d.get()`, you obtain a value zero.

Using the `printf` statements, you can see that you retrieve a value that is different from the value that you set.

The defect appears in the final derived class definition and on the name of the class that are derived virtually from the common base class. Following are some tips for navigating in the source code:

- To find the definition of a class, on the **Source** pane, right-click the class name and select **Go To Definition**.
- To navigate up the class hierarchy, first navigate to the intermediate class definition. In the intermediate class definition, right-click a base class name and select **Go To Definition**.

Correction — Make Both Inheritances Virtual

One possible correction is to declare both the inheritances from `Base` as `virtual`.

Even though the overridden `get` and `set` methods in `Final` still call `Base::get` and `Base::set` through different classes, only one copy of `m_b` exists in `Final`.

```
#include <stdio.h>
class Base {
public:
    explicit Base(int i): m_b(i) {};
    virtual ~Base() {};
    virtual int get() const {
        return m_b;
    }
    virtual void set(int b) {
        m_b = b;
    }
private:
    int m_b;
};

class Intermediate_left: virtual public Base {
public:
    Intermediate_left():Base(0), m_d1(0) {};
private:
    int m_d1;
};

class Intermediate_right: virtual public Base {
public:
    Intermediate_right():Base(0), m_d2(0) {};
private:
    int m_d2;
```

```
};

class Final: public Intermediate_left, Intermediate_right {
public:
    Final(): Base(0), Intermediate_left(), Intermediate_right() {};
    int get() const {
        return Intermediate_left::get();
    }
    void set(int b) {
        Intermediate_right::set(b);
    }
    int get2() const {
        return Intermediate_right::get();
    }
};

int main(int argc, char* argv[]) {
    Final d;
    int val = 12;
    d.set(val);
    int res = d.get();
    printf("d.get=%d\n",res);             // Result: d.get=12
    printf("d.get2=%d\n",d.get2());       // Result: d.get2=12
    return res;
}
```

Result Information

Group: Object oriented
Language: C++
Default: Off
Command-Line Syntax: `MISSING_VIRTUAL_INHERITANCE`
Impact: Medium

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Line with more than one statement

Multiple statements on a line

Description

Before preprocessing starts, **Line with more than one statement** checks for additional text after the semicolon (`;`) on a line. A defect is not raised for comments, `for`-loop definitions, braces, or backslashes.

Risk

Use of one statement per line improves readability of the code. Since most statements in your code appear on a new line, use of multiple statements per line in a few cases within this arrangement can make code review difficult.

Fix

Write one statement per line.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Single-Line Initialization

```
int multi_init(void){
_    int abc = 4; int efg = 0; //defect

    return abc*efg;
}
```

In this example, `abc` and `efg` are initialized on the second line of the function as separate statements.

Correction — Comma-Separated Initialization

One possible correction is to use a comma instead of a semicolon to declare multiple variables on the same line.

```
int multi_init(void){
    int a = 4, b = 0;

    return a*b;
}
```

Correction — New Line for Each Initialization

One possible correction is to separate each initialization. By putting the initialization of `b` on the next line, the code longer raises a defect.

```
int multi_init(void){
    int a = 4;
    int b = 0;

    return a*b;
}
```

Single-Line Loops

```
int multi_loop(void){
    int a, b = 0;
    int index = 1;
    int tab[9] = {1,1,2,3,5,8,13,21};

    for(a=0; a < 3; a++) {b+=a;} // no defect

_   for(b=0; b < 3; b++) {a+=b; index=b;} //defect

_   while (index < 7) {index++; tab[index] = index * index;} //defect
    return a*b;
}
```

In this example, there are three loops coded on single lines, each with multiple semicolons.

- The first `for` loop has multiple semicolons. Polyspace does not raise a defect for multiple statements within a `for` loop declaration.

- Polyspace does raise a defect on the second `for` loop because there are multiple statements after the `for` loop declaration.
- The `while` loop also has multiple statements after the loop declaration. Polyspace raises a defect on this line.

Correction — New Line for Each Loop Statement

One possible correction is to use a new line for each statement after the loop declaration.

```
int multi_loop(void){
    int a, b = 0;
    int index = 1;
    int tab[9] = {1,1,2,3,5,8,13,21};

    for(a=0; a < 3; a++) {b+=a;}

    for(b=0; b < 3; b++){
      a+=b;
      index=b;
    }

    while (index < 7){
      index++;
      tab[index] = index * index;
    }
    return a*b;
}
```

Single-line Conditionals

```
int multi_if(void){

    int a, b = 1;
    if(a == 0) { a++;} // no defect
_    else if(b == 1) {b++; a *= b;} //defect
}
```

In this example, there are two conditional statements an: `if` and an `else if`. The `if` line does not raise a defect because only one statement follows the condition. The `else if` statement does raise a defect because two statements follow the condition.

Correction — New Lines for Multi-Statement Conditionals

One possible correction is to use a new line for conditions with multiple statements.

```
int multi_if(void){
    int a, b = 1;

    if(a == 0) a++;
    else if(b == 1){
      b++;
      a *= b;
    }
}
```

Check Information

Group: Good practice
Language: C | C++
Default: Off
Command-Line Syntax: `MORE_THAN_ONE_STATEMENT`
Impact: Low

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Ambiguous declaration syntax

Declaration syntax can be interpreted as object declaration or part of function declaration

Description

Ambiguous declaration syntax occurs when it is not clear from a declaration whether an object declaration or function/parameter declaration is intended. The ambiguity is often referred to as most vexing parse.

For instance, these declarations are ambiguous:

- `ResourceType aResource();`

  It is not immediately clear if `aResource` is a function returning a variable of type `ResourceType` or an object of type `ResourceType`.
- `TimeKeeper aTimeKeeper(Timer());`

  It is not immediately clear if `aTimeKeeper` is an object constructed with an unnamed object of type `Timer` or a function with an unnamed function pointer type as parameter. The function pointer refers to a function with no argument and return type `Timer`.

Risk

In case of an ambiguous declaration, the C++ Standard chooses a specific interpretation of the syntax. For instance:

- `ResourceType aResource();`

  is interpreted as a declaration of a function `aResource`.
- `TimeKeeper aTimeKeeper(Timer());`

  is interpreted as a declaration of a function `aTimeKeeper` with an unnamed parameter of function pointer type.

If you or another developer or code reviewer expects a different interpretation, the results can be unexpected.

For instance, later you might face a compilation error that is difficult to understand. Since the default interpretation indicates a function declaration, if you use the function as an object, compilers might report a compilation error. The compilation error indicates that a conversion from a function to an object is being attempted without a suitable constructor.

Fix

Make the declaration unambiguous. For instance, fix these ambiguous declarations as follows:

- `ResourceType aResource();`

  Object declaration:

  If the declaration refers to an object initialized with the default constructor, rewrite it as:

  ```
  ResourceType aResource;
  ```

  prior to C++11, or as:

  ```
  ResourceType aResource{};
  ```

  after C++11.

  Function declaration:

  If the declaration refers to a function, use a typedef for the function.

  ```
  typedef ResourceType(*resourceFunctionType)();
  resourceFunctionType aResource;
  ```

- `TimeKeeper aTimeKeeper(Timer());`

  Object declaration:

  If the declaration refers to an object `aTimeKeeper` initialized with an unnamed object of class `Timer`, add an extra pair of parenthesis:

  ```
  TimeKeeper aTimeKeeper( (Timer()) );
  ```

  prior to C++11, or use braces:

  ```
  TimeKeeper aTimeKeeper{Timer{}};
  ```

after C++11.

Function declaration:

If the declaration refers to a function `aTimeKeeper` with a unnamed parameter of function pointer type, use a named parameter instead.

```
typedef Timer(*timerType)();
TimeKeeper aTimeKeeper(timerType aTimer);
```

Examples

Function or Object Declaration

```
class ResourceType {
      int aMember;
    public:
      int getMember();
};

void getResource() {
    ResourceType aResource();
}
```

In this example, `aResource` might be used as an object but the declaration syntax indicates a function declaration.

Correction — Use {} for Object Declaration

One possible correction (after C++11) is to use braces for object declaration.

```
class ResourceType {
      int aMember;
    public:
      int getMember();
};

void getResource() {
    ResourceType aResource{};
}
```

Unnamed Object or Unnamed Function Parameter Declaration

```
class MemberType {};

class ResourceType {
      MemberType aMember;
    public:
      ResourceType(MemberType m) {aMember = m;}
      int getMember();
};

void getResource() {
    ResourceType aResource(MemberType());
}
```

In this example, `aResource` might be used as an object initialized with an unnamed object of type `MemberType` but the declaration syntax indicates a function with an unnamed parameter of function pointer type. The function pointer points to a function with no arguments and type `MemberType`.

Correction — Use {} for Object Declaration

One possible correction (after C++11) is to use braces for object declaration.

```
class MemberType {};

class ResourceType {
      MemberType aMember;
    public:
      ResourceType(MemberType m) {aMember = m;}
      int getMember();
};

void getResource {
    ResourceType aResource{MemberType()};
}
```

Unnamed Object or Named Function Parameter Declaration

```
class Integer {
       int aMember;
    public:
       Integer(int d) {aMember = d;}
```

```
       int getMember();
};

int aInt = 0;
Integer aInteger(Integer(aInt));
```

In this example, `aInteger` might be an object constructed with an unnamed object `Integer(aInt)` (an object of class `Integer` which itself is constructed using the variable `aInt`). However, the declaration syntax indicates that `aInteger` is a function with a named parameter `aInt` of type `Integer` (the superfluous parenthesis is ignored).

Correction — Use of {} for Object Declaration

One possible correction (after C++11) is to use {} for object declaration.

```
class Integer {
       int aMember;
    public:
       Integer(int d) {aMember = d;}
       int getMember();
};

int aInt = 0;
Integer aInteger{Integer{aInt}};
```

Correction — Remove Superfluous Parenthesis for Named Parameter Declaration

If `aInteger` is a function with a named parameter `aInt`, remove the superfluous () around `aInt`.

```
class Integer {
       int aMember;
    public:
       Integer(int d) {aMember = d;}
       int getMember();
};

Integer aInteger(Integer aInt);
```

Result Information

Group: Good practice
Language: C++

Default: Off
Command-Line Syntax: `MOST_VEXING_PARSE`
Impact: Low

See Also

`Improper array initialization` | `Non-initialized variable` | `Variable shadowing` | `Write without a further read`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2019a

Misuse of narrow or wide character string

Narrow (wide) character string passed to wide (narrow) string function

Description

Misuse of narrow or wide character string occurs when you pass a narrow character string to a wide string function, or a wide character string to a narrow string function.

Misuse of narrow or wide character string raises no defect on operating systems where narrow and wide character strings have the same size.

Risk

Using a narrow character string with a wide string function, or vice versa, can result in unexpected or undefined behavior.

If you pass a wide character string to a narrow string function, you can encounter these issues:

- Data truncation. If the string contains null bytes, a copy operation using `strncpy()` can terminate early.
- Incorrect string length. `strlen()` returns the number of characters of a string up to the first null byte. A wide string can have additional characters after its first null byte.

If you pass a narrow character string to a wide string function, you can encounter this issue:

- Buffer overflow. In a copy operation using `wcsncpy()`, the destination string might have insufficient memory to store the result of the copy.

Fix

Use the narrow string functions with narrow character strings. Use the wide string functions with wide character strings.

Examples

Passing Wide Character Strings to `strncpy()`

```
#include <string.h>
#include <wchar.h>

void func(void)
{
    wchar_t wide_str1[]  = L"0123456789";
    wchar_t wide_str2[] =  L"0000000000";
    strncpy(wide_str2, wide_str1, 10);
}
```

In this example, `strncpy()` copies 10 wide characters from `wide_strt1` to `wide_str2`. If `wide_str1` contains null bytes, the copy operation can end prematurely and truncate the wide character string.

Correction — Use `wcsncpy()` to Copy Wide Character Strings

One possible correction is to use `wcsncpy()` to copy `wide_str1` to `wide_str2`.

```
#include <string.h>
#include <wchar.h>

void func(void)
{
    wchar_t wide_str1[]  = L"0123456789";
    wchar_t wide_str2[] =  L"0000000000";
    wcsncpy(wide_str2, wide_str1, 10);
}
```

Result Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: `NARROW_WIDE_STR_MISUSE`
Impact: High
CWE ID: 135

See Also

`Array access out of bounds` | `Destination buffer overflow in string manipulation` | `Invalid use of standard library routine` | `Invalid use of standard library string routine` | `Pointer access out of bounds` | `Unreliable cast of function pointer` | `Wrong allocated object size for cast`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

Member not initialized in constructor

Constructor does not initialize some members of a class

Description

Non-initialized member occurs when a class constructor has at least one execution path on which it does not initialize some data members of the class.

The defect does not appear in the following cases:

- Empty constructors.
- The non-initialized member is not used in the code.

Risk

The members that the constructor does not initialize can have unintended values when you read them later.

Initializing all members in the constructor makes it easier to use your class. If you call a separate method to initialize your members and then read them, you can avoid uninitialized values. However, someone else using your class can read a class member *before* calling your initialization method. Because a constructor is called when you create an object of the class, if you initialize all members in the constructor, they cannot have uninitialized values later on.

Fix

The best practice is to initialize all members in your constructor, preferably in an initialization list.

Examples

Non-Initialized Member

```
class MyClass {
public:
    explicit MyClass(int);
private:
    int _i;
    char _c;
};

MyClass::MyClass(int flag) {
    if(flag == 0) {
        _i = 0;
        _c = 'a';
    }
    else {
        _i = 1;
    }
}
```

In this example, if `flag` is not 0, the member `_c` is not initialized.

The defect appears on the closing brace of the constructor. Following are some tips for navigating in the source code:

- On the **Result Details** pane, see which members are not initialized.
- To navigate to the class definition, right-click a member that is initialized in the constructor. Select **Go To Definition**. In the class definition, you can see all the members, including those members that are not initialized in the constructor.

Correction — Initialize All Members on All Execution Paths

One possible correction is to initialize all members of the class `MyClass` for all values of `flag`.

```
class MyClass {
public:
    explicit MyClass(int);
private:
    int _i;
```

```
    char _c;
};

MyClass::MyClass(int flag) {
    if(flag == 0) {
        _i = 0;
        _c = 'a';
    }
    else {
        _i = 1;
        _c = 'b';
    }
}
```

Result Information

Group: Object oriented
Language: C++
Default: Off
Command-Line Syntax: `NON_INIT_MEMBER`
Impact: Medium
CWE ID: 456, 457, 908

See Also

`Copy constructor not called in initialization list`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Non-initialized pointer

Pointer not initialized before dereference

Description

Non-initialized pointer occurs when a pointer is not assigned an address before dereference.

Risk

Unless a pointer is explicitly assigned an address, it points to an unpredictable location.

Fix

The fix depends on the root cause of the defect. For instance, you assigned an address to the pointer but the assignment is unreachable.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below. It is a good practice to initialize a pointer to NULL when declaring the pointer.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Non-initialized pointer error

```
#include <stdlib.h>
```

```
int* assign_pointer(int* prev)
{
    int j = 42;
    int* pi;

    if (prev == NULL)
      {
        pi = (int*)malloc(sizeof(int));
        if (pi == NULL) return NULL;
      }

    *pi = j;
    /* Defect: Writing to uninitialized pointer */

    return pi;
}
```

If `prev` is not `NULL`, the pointer `pi` is not assigned an address. However, `pi` is dereferenced on every execution paths, irrespective of whether `prev` is `NULL` or not.

Correction — Initialize Pointer on Every Execution Path

One possible correction is to assign an address to `pi` when `prev` is not `NULL`.

```
#include <stdlib.h>

int* assign_pointer(int* prev)
{
    int j = 42;
    int* pi;

    if (prev == NULL)
       {
        pi = (int*)malloc(sizeof(int));
        if (pi == NULL) return NULL;
       }
    /* Fix: Initialize pi in branches of if statement  */
    else
        pi = prev;


    *pi = j;

    return pi;
}
```

Check Information

Group: Data flow
Language: C | C++
Default: On
Command-Line Syntax: `NON_INIT_PTR`
Impact: High
CWE ID: 456, 457, 824, 908

See Also

`Non-initialized variable`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Pointer to non-initialized value converted to const pointer

Pointer to constant assigned address that does not contain a value

Description

Pointer to non initialized value converted to const pointer occurs when a pointer to a constant (`const int*`, `const char*`, etc.) is assigned an address that does not yet contain a value.

Risk

A pointer to a constant stores a value that must not be changed later in the program. If you assign the address of a non-initialized variable to the pointer, it now points to an address with garbage values for the remainder of the program.

Fix

Initialize a variable before assigning its address to a pointer to a constant.

Examples

Pointer to non initialized value converted to const pointer error

```
#include<stdio.h>

void Display_Parity()
 {
  int num,parity;
  const int* num_ptr = &num;
  /* Defect: Address &num does not store a value */
```

```
  printf("Enter a number\n:");
  scanf("%d",&num);

  parity=((*num_ptr)%2);
  if(parity==0)
    printf("The number is even.");
  else
    printf("The number is odd.");

 }
```

`num_ptr` is declared as a pointer to a constant. However the variable `num` does not contain a value when `num_ptr` is assigned the address `&num`.

Correction — Store Value in Address Before Assignment to Pointer

One possible correction is to obtain the value of `num` from the user before `&num` is assigned to `num_ptr`.

```
#include<stdio.h>

void Display_Parity()
 {
  int num,parity;
  const int* num_ptr;

  printf("Enter a number\n:");
  scanf("%d",&num);

 /* Fix: Assign &num to pointer after it receives a value */
  num_ptr=&num;
  parity=((*num_ptr)%2);
  if(parity==0)
    printf("The number is even.");
  else
    printf("The number is odd.");
 }
```

The `scanf` statement stores a value in `&num`. Once the value is stored, it is legitimate to assign `&num` to `num_ptr`.

Check Information

Group: Data flow
Language: C | C++
Default: Off
Command-Line Syntax: `NON_INIT_PTR_CONV`
Impact: Medium

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Non-initialized variable

Variable not initialized before use

Description

Non-initialized variable occurs when a variable is not initialized before its value is read.

Risk

Unless a variable is explicitly initialized, the variable value is unpredictable. You cannot rely on the variable having a specific value.

Fix

The fix depends on the root cause of the defect. For instance, you assigned a value to the variable but the assignment is unreachable or you assigned a value to the variable in one of two branches of a conditional statement. Fix the unreachable code or missing assignment.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below. It is a good practice to initialize a variable at declaration.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Non-initialized variable error

```
int get_sensor_value(void)
{
```

```
    extern int getsensor(void);
    int command;
    int val;

    command = getsensor();
    if (command == 2)
      {
        val = getsensor();
      }

    return val;
    /* Defect: val does not have a value if command is not 2 */
}
```

If `command` is not 2, the variable `val` is unassigned. In this case, the return value of function `get_sensor_value` is undetermined.

Correction — Initialize During Declaration

One possible correction is to initialize `val` during declaration so that the initialization is not bypassed on some execution paths.

```
int get_sensor_value(void)
{
    extern int getsensor(void);
    int command;
    /* Fix: Initialize val */
    int val=0;

    command = getsensor();
    if (command == 2)
      {
        val = getsensor();
      }

    return val;
 }
```

`val` is assigned an initial value of 0. When `command` is not equal to 2, the function `get_sensor_value` returns this value.

Check Information

Group: Data flow
Language: C | C++
Default: On
Command-Line Syntax: `NON_INIT_VAR`
Impact: High
CWE ID: 456, 457, 908

See Also

`Non-initialized pointer`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Variable length array with nonpositive size

Size of variable-length array is zero or negative

Description

Variable length array with non-positive size occurs when size of a variable-length array is zero or negative.

Risk

If the size of a variable-length array is zero or negative, unexpected behavior can occur, such as stack overflow.

Fix

When you declare a variable-length array as a local variable in a function:

- If you use a function parameter as the array size, check that the parameter is positive.
- If you use the result of a computation on a function parameter as the array size, check that the result is positive.

You can place a test for positive value either before the function call or the array declaration in the function body.

Examples

Nonpositive Array Size

```
int input(void);

void add_scalar(int n, int m) {
    int r=0;
    int arr[m][n];
    for (int i=0; i<m; i++) {
```

```
        for (int j=0; j<n; j++) {
            arr[i][j] = input();
            r += arr[i][j];
        }
    }
}

void main() {
    add_scalar(2,2);
    add_scalar(-1,2);
    add_scalar(2,0);
}
```

In this example, the second and third calls to `add_scalar` result in a negative and zero size of `arr`.

Correction — Make Array Size Positive

One possible correction is fix or remove calls that result in a nonpositive array size.

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `NON_POSITIVE_VLA_SIZE`
Impact: High
CWE ID: 687

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Misuse of return value from nonreentrant standard function

Pointer to static buffer from previous call is used despite a subsequent call that modifies the buffer

Description

Misuse of return value from nonreentrant standard function occurs when these events happen in this sequence:

1. You point to the buffer returned from a nonreentrant standard function such as `getenv` or `setlocale`.

   ```
   user = getenv("USER");
   ```

2. You call that nonreentrant standard function again.

   ```
   user2 = getenv("USER2");
   ```

3. You use or dereference the pointer from the first step expecting the buffer to remain unmodified since that step. In the meantime, the call in the second step has modified the buffer.

   For instance:

   ```
   var=*user;
   ```

In some cases, the defect might appear even if you do not call the `getenv` function a second time but simply return the pointer. For instance:

```
char* func() {
     user=getenv("USER");
     .
     .
     return user;
}
```

For information on which functions are covered by this defect, see documentation on nonreentrant standard functions.

Risk

The C Standard allows nonreentrant functions such as `getenv` to return a pointer to a *static* buffer. Because the buffer is static, a second call to `getenv` modifies the buffer. If you continue to use the pointer returned from the first call past the second call, you can see unexpected results. The buffer that it points to no longer has values from the first call.

The defect appears even if you do not call `getenv` a second time but simply return the pointer. The reason is that someone calling your function might use the returned pointer *after* a second call to `getenv`. By returning the pointer from your call to `getenv`, you make your function unsafe to use.

The same rationale is true for other nonreentrant functions covered by this defect.

Fix

After the first call to `getenv`, make a copy of the buffer that the returned pointer points to. After the second call to `getenv`, use this copy. Even if the second call modifies the buffer, your copy is untouched.

Examples

Return from `getenv` Used After Second Call to `getenv`

```
#include <stdlib.h>
#include <string.h>

int func()
{
    int result = 0;

    char *home = getenv("HOME");   /* First call */
    if (home != NULL) {
        char *user = NULL;
        char *user_name_from_home = strrchr(home, '/');

        if (user_name_from_home != NULL) {
            user = getenv("USER");   /* Second call */
            if ((user != NULL) &&
                (strcmp(user, user_name_from_home) == 0))
```

```
            {
                result = 1;
            }
        }
    }
    return result;
}
```

In this example, the pointer `user_name_from_home` is derived from the pointer `home`. `home` points to the buffer returned from the first call to `getenv`. Therefore, `user_name_from_home` points to a location in the same buffer.

After the second call to `getenv`, the buffer is modified. If you continue to use `user_name_from_home`, you can get unexpected results.

Correction — Make Copy of Buffer Before Second Call

If you want to access the buffer from the first call to `getenv` past the second call, make a copy of the buffer after the first call. One possible correction is to use the `strdup` function to make the copy.

```
#include <stdlib.h>
#include <string.h>

int func()
{
    int result = 0;

    char *home = getenv("HOME");
    if (home != NULL) {
        char *user = NULL;
        char *user_name_from_home = strrchr(home, '/');
        if (user_name_from_home != NULL) {
            /* Make copy before second call */
            char *saved_user_name_from_home = strdup(user_name_from_home);
            if (saved_user_name_from_home != NULL) {
                user = getenv("USER");
                if ((user != NULL) &&
                    (strcmp(user, saved_user_name_from_home) == 0))
                {
                    result = 1;
                }
                free(saved_user_name_from_home);
            }
```

```
        }
    }
    return result;
}
```

Result Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: `NON_REENTRANT_STD_RETURN`
Impact: High

See Also

`Modification of internal buffer returned from nonreentrant standard function` | `Use of obsolete standard function`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Use of non-secure temporary file

Temporary generated file name not secure

Description

Use of non-secure temporary file looks for temporary file routines that are not secure.

Risk

If an attacker guesses the file name generated by a standard temporary file routine, the attacker can:

- Cause a race condition when you generate the file name.
- Precreate a file of the same name, filled with malicious content. If your program reads the file, the attacker's file can inject the malicious code.
- Create a symbolic link to a file storing sensitive data. When your program writes to the temporary file, the sensitive data is deleted.

Fix

To create temporary files, use a more secure standard temporary file routine, such as `mkstemp` from POSIX.1-2001.

Also, when creating temporary files with routines that allow flags, such as `mkostemp`, use the exclusion flag `O_EXCL` to avoid race conditions.

Examples

Temp File Created With `tempnam`

```
#define _BSD_SOURCE
#define _XOPEN_SOURCE
#define _GNU_SOURCE
```

```
#include <stdio.h>
#include <stdlib.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <fcntl.h>
#include <unistd.h>

int test_temp()
{
    char tpl[] = "abcXXXXXX";
    char suff_tpl[] = "abcXXXXXXsuff";
    char *filename = NULL;
    int fd;

    filename = tempnam("/var/tmp", "foo_");

    if (filename != NULL)
    {
        printf("generated tmp name (%s) in (%s:%s:%s)\n",
               filename, getenv("TMPDIR") ? getenv("TMPDIR") : "$TMPDIR",
               "/var/tmp", P_tmpdir);

        fd = open(filename, O_CREAT, S_IRWXU|S_IRUSR);
        if (fd != -1)
        {
            close(fd);
            unlink(filename);
            return 1;
        }
    }
    return 0;
}
```

In this example, Bug Finder flags `open` because it tries to use an unsecure temporary file. The file is opened without exclusive privileges. An attacker can access the file causing various risks on page 1-544.

Correction — Add O_EXCL Flag

One possible correction is to add the `O_EXCL` flag when you open the temporary file.

```
#define _BSD_SOURCE
#define _XOPEN_SOURCE
#define _GNU_SOURCE
```

```
#include <stdio.h>
#include <stdlib.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <fcntl.h>
#include <unistd.h>

int test_temp()
{
    char tpl[] = "abcXXXXXX";
    char suff_tpl[] = "abcXXXXXXsuff";
    char *filename = NULL;
    int fd;

    filename = tempnam("/var/tmp", "foo_");

    if (filename != NULL)
    {
        printf("generated tmp name (%s) in (%s:%s:%s)\n",
               filename, getenv("TMPDIR") ? getenv("TMPDIR") : "$TMPDIR",
               "/var/tmp", P_tmpdir);

        fd = open(filename, O_CREAT|O_EXCL, S_IRWXU|S_IRUSR);
        if (fd != -1)
        {
            close(fd);
            unlink(filename);
            return 1;
        }
    }
    return 0;
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: NON_SECURE_TEMP_FILE
Impact: High
CWE ID: 377, 922

See Also

`Data race`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Null pointer

NULL pointer dereferenced

Description

Null pointer occurs when you use a pointer with a value of NULL as if it points to a valid memory location.

Risk

Dereferencing a null pointer is undefined behavior. In most implementations, the dereference can cause your program to crash.

Fix

Check a pointer for NULL before dereference.

If the issue occurs despite an earlier check for NULL, look for intermediate events between the check and the subsequent dereference. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

Examples

Null pointer error

```
#include <stdlib.h>

int FindMax(int *arr, int Size)
{
```

```
 int* p=NULL;

 *p=arr[0];
 /* Defect: Null pointer dereference */

 for(int i=0;i<Size;i++)
  {
   if(arr[i] > (*p))
     *p=arr[i];
  }

 return *p;
}
```

The pointer `p` is initialized with value of `NULL`. However, when the value `arr[0]` is written to `*p`, `p` is assumed to point to a valid memory location.

Correction — Assign Address to Null Pointer Before Dereference

One possible correction is to initialize `p` with a valid memory address before dereference.

```
#include <stdlib.h>

int FindMax(int *arr, int Size)
{
 /* Fix: Assign address to null pointer */
 int* p=&arr[0];

 for(int i=0;i<Size;i++)
  {
   if(arr[i] > (*p))
     *p=arr[i];
  }

 return *p;
}
```

Check Information

Group: Static memory
Language: C | C++
Default: On
Command-Line Syntax: `NULL_PTR`

Impact: High
CWE ID: 476, 690

See Also

`Arithmetic operation with NULL pointer` | `Non-initialized pointer`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Arithmetic operation with NULL pointer

Arithmetic operation performed on `NULL` pointer

Description

Arithmetic operation with NULL pointer occurs when an arithmetic operation involves a pointer whose value is `NULL`.

Risk

Performing pointer arithmetic on a null pointer and dereferencing the resulting pointer is undefined behavior. In most implementations, the dereference can cause your program to crash.

Fix

Check a pointer for `NULL` before arithmetic operations on the pointer.

If the issue occurs despite an earlier check for `NULL`, look for intermediate events between the check and the subsequent dereference. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

Examples

Arithmetic Operation with NULL Pointer Error

```
#include<stdlib.h>

int Check_Next_Value(int *loc, int val)
```

```
{
 int *ptr = loc, found = 0;

 if (ptr==NULL)
  {
     ptr++;
     /* Defect: NULL pointer shifted */

     if (*ptr==val) found=1;
  }

 return(found);
}
```

When `ptr` is a `NULL` pointer, the code enters the `if` statement body. Therefore, a `NULL` pointer is shifted in the statement `ptr++`.

Correction — Avoid NULL Pointer Arithmetic

One possible correction is to perform the arithmetic operation when `ptr` is not `NULL`.

```
#include<stdlib.h>

int Check_Next_Value(int *loc, int val)
 {
  int *ptr = loc, found = 0;

  /* Fix: Perform operation when ptr is not NULL */
  if (ptr!=NULL)
   {
     ptr++;

     if (*ptr==val) found=1;
   }

  return(found);
 }
```

Check Information

Group: Static memory
Language: C | C++
Default: Off

Command-Line Syntax: `NULL_PTR_ARITH`
Impact: Low

See Also

`Null pointer`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Wrong allocated object size for cast

Allocated memory does not match destination pointer

Description

Wrong allocated object size for cast occurs during pointer conversion when the pointer's address is misaligned. If a pointer is converted to a different pointer type, the size of the allocated memory must be a multiple of the size of the destination pointer.

Risk

Dereferencing a misaligned pointer has undefined behavior and can cause your program to crash.

Fix

Suppose you convert a pointer `ptr1` to `ptr2`. If `ptr1` points to a buffer of `N` bytes and `ptr2` is a *`type`* `*` pointer where `sizeof(`*`type`*`)` is `n` bytes, make sure that `N` is an integer multiple of `n`.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See "Address Polyspace Results Through Bug Fixes or Comments".

Examples

Dynamic Allocation of Pointers

```
#include <stdlib.h>

void dyn_non_align(void){
    void *ptr = malloc(13);
    long *dest;
```

```
    dest = (long*)ptr; //defect
}
```

In this example, the software raises a defect on the conversion of `ptr` to a `long*`. The dynamically allocated memory of `ptr`, 13 bytes, is not a multiple of the size of `dest`, 4 bytes. This misalignment causes the **Wrong allocated object size for cast** defect.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the allocated memory to 12 instead of 13.

```
#include <stdlib.h>

void dyn_non_align(void){
    void *ptr = malloc(12);
    long *dest;

    dest = (long*)ptr;
}
```

Static Allocation of Pointers

```
void static_non_align(void){
    char arr[13], *ptr;
    int *dest;

    ptr = &arr[0];
    dest = (int*)ptr; //defect
}
```

In this example, the software raises a defect on the conversion of `ptr` to an `int*` in line 6. `ptr` has a memory size of 13 bytes because the array `arr` has a size of 13 bytes. The size of `dest` is 4 bytes, which is not a multiple of 13. This misalignment causes the **Wrong allocated object size for cast** defect.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the size of the array `arr` to a multiple of 4.

```
void static_non_align(void){
    char arr[12], *ptr;
```

```
    int *dest;

    ptr = &arr[0];
    dest = (int*)ptr;
}
```

Allocation with a Function

```
#include <stdlib.h>

void *my_alloc(int size) {
    void *ptr_func = malloc(size);
    if(ptr_func == NULL) exit(-1);
    return ptr_func;
}

void fun_non_align(void){
    int *dest1;
    char *dest2;

    dest1 = (int*)my_alloc(13);  //defect
    dest2 = (char*)my_alloc(13); //not a defect
}
```

In this example, the software raises a defect on the conversion of the pointer returned by `my_alloc(13)` to an `int*` in line 11. `my_alloc(13)` returns a pointer with a dynamically allocated size of 13 bytes. The size of `dest1` is 4 bytes, which is not a divisor of 13. This misalignment causes the **Wrong allocated object size for cast** defect. In line 12, the same function call, `my_alloc(13)`, does not call a defect for the conversion to `dest2` because the size of `char*`, 1 byte, a divisor of 13.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the argument for `my_alloc` to a multiple of 4.

```
#include <stdlib.h>

void *my_alloc(int size) {
    void *ptr_func = malloc(size);
    if(ptr_func == NULL) exit(-1);
    return ptr_func;
```

```
}

void fun_non_align(void){
    int *dest1;
    char *dest2;

    dest1 = (int*)my_alloc(12);
    dest2 = (char*)my_alloc(13);
}
```

Check Information

Group: Static Memory
Language: C | C++
Default: Off
Command-Line Syntax: OBJECT_SIZE_MISMATCH
Impact: High
CWE ID: 704

See Also

Unreliable cast of pointer

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Object slicing

Derived class object passed by value to function with base class parameter

Description

Object slicing occurs when you pass a derived class object by value to a function, but the function expects a base class object as parameter.

Risk

If you pass a derived class object *by value* to a function, you expect the derived class copy constructor to be called. If the function expects a base class object as parameter:

1. The base class copy constructor is called.
2. In the function body, the parameter is considered as a base class object.

In C++, `virtual` methods of a class are resolved at run time according to the actual type of the object. Because of object slicing, an incorrect implementation of a `virtual` method can be called. For instance, the base class contains a `virtual` method and the derived class contains an implementation of that method. When you call the `virtual` method from the function body, the base class method is called, even though you pass a derived class object to the function.

Fix

One possible fix is to pass the object by reference or pointer. Passing by reference or pointer does not cause invocation of copy constructors. If you do not want the object to be modified, use a `const` qualifier with your function parameter.

Another possible fix is to overload the function with another function that accepts the derived class object as parameter.

Examples

Function Call Causing Object Slicing

```
#include <iostream>

class Base {
public:
    explicit Base(int b) {
        _b = b;
    }
    virtual ~Base() {}
    virtual int update() const;
protected:
    int _b;
};


class Derived: public Base {
public:
    explicit Derived(int b):Base(b) {}
    int update() const;
};

//Class methods definition

int Base::update() const {
    return (_b + 1);
}

int Derived::update() const {
    return (_b -1);
}


//Other function definitions
void funcPassByValue(const Base bObj) {
    std::cout << "Updated _b=" << bObj.update() << std::endl;
}

int main() {
    Derived dObj(0);
    funcPassByValue(dObj);       //Function call slices object
```

```
    return 0;
 }
```

In this example, the call `funcPassByValue(dObj)` results in the output `Updated _b=1` instead of the expected `Updated _b=-1`. Because `funcPassByValue` expects a `Base` object parameter, it calls the `Base` class copy constructor.

Therefore, even though you pass the `Derived` object `dObj`, the function `funcPassByValue` treats its parameter `b` as a `Base` object. It calls `Base::update()` instead of `Derived::update()`.

Correction — Pass Object by Reference or Pointer

One possible correction is to pass the `Derived` object `dObj` by reference or by pointer. In the following, corrected example, `funcPassByReference` and `funcPassByPointer` have the same objective as `funcPassByValue` in the preceding example. However, `funcPassByReference` expects a reference to a `Base` object and `funcPassByPointer` expects a pointer to a `Base` object.

Passing the `Derived` object `d` by a pointer or by reference does not slice the object. The calls `funcPassByReference(dObj)` and `funcPassByPointer(&dObj)` produce the expected result `Updated _b=-1`.

```
#include <iostream>

class Base {
public:
    explicit Base(int b) {
        _b = b;
    }
    virtual ~Base() {}
    virtual int update() const;
protected:
    int _b;
};


class Derived: public Base {
public:
    explicit Derived(int b):Base(b) {}
    int update() const;
};

//Class methods definition
```

```
int Base::update() const {
    return (_b + 1);
}

int Derived::update() const {
    return (_b -1);
}


//Other function definitions
void funcPassByReference(const Base& bRef) {
    std::cout << "Updated _b=" << bRef.update() << std::endl;
}

void funcPassByPointer(const Base* bPtr) {
    std::cout << "Updated _b=" << bPtr->update() << std::endl;
}

int main() {
    Derived dObj(0);
    funcPassByReference(dObj);       //Function call does not slice object
    funcPassByPointer(&dObj);       //Function call does not slice object
    return 0;
 }
```

Note If you pass by value, because a copy of the object is made, the original object is not modified. Passing by reference or by pointer makes the object vulnerable to modification. If you are concerned about your original object being modified, add a `const` qualifier to your function parameter, as in the preceding example.

Result Information

Group: Object oriented
Language: C++
Default: On
Command-Line Syntax: `OBJECT_SLICING`
Impact: High

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Use of obsolete standard function

Obsolete routines can cause security vulnerabilities and portability issues

Description

Use of obsolete standard function detects calls to standard function routines that are considered legacy, removed, deprecated, or obsolete by C/C++ coding standards.

Obsolete Function	Standards	Risk	Replacement Function
`asctime`	Deprecated in POSIX.1-2008	Not thread-safe.	`strftime` or `asctime_s`
`asctime_r`	Deprecated in POSIX.1-2008	Implementation based on unsafe function `sprintf`.	`strftime` or `asctime_s`
`bcmp`	Deprecated in 4.3BSD Marked as legacy in POSIX.1-2001.	Returns from function after finding the first differing byte, making it vulnerable to timing attacks.	`memcmp`
`bcopy`	Deprecated in 4.3BSD Marked as legacy in POSIX.1-2001.	Returns from function after finding the first differing byte, making it vulnerable to timing attacks.	`memcpy` or `memmove`
`brk` and `sbrk`	Marked as legacy in SUSv2 and POSIX.1-2001.		`malloc`
`bsd_signal`	Removed in POSIX.1-2008		`sigaction`
`bzero`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`memset`
`ctime`	Deprecated in POSIX.1-2008	Not thread-safe.	`strftime` or `asctime_s`

Obsolete Function	Standards	Risk	Replacement Function
`ctime_r`	Deprecated in POSIX.1-2008	Implementation based on unsafe function `sprintf`.	`strftime` or `asctime_s`
`cuserid`	Removed in POSIX.1-2001.	Not reentrant. Precise functionality not standardized causing portability issues.	`getpwuid`
`ecvt` and `fcvt`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008	Not reentrant	`snprintf`
`ecvt_r` and `fcvt_r`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008		`snprintf`
`ftime`	Removed in POSIX.1-2008		`time`, `gettimeofday`, `clock_gettime`
`gamma`, `gammaf`, `gammal`	Function not specified in any standard because of historical variations	Portability issues.	`tgamma`, `lgamma`
`gcvt`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`snprintf`
`getcontext`	Removed in POSIX.1-2008.	Portability issues.	Use POSIX thread instead.
`getdtablesize`	BSD API function not included in POSIX.1-2001	Portability issues.	`sysconf( _SC_OPEN_MAX )`
`gethostbyaddr`	Removed in POSIX.1-2008	Not reentrant	`getaddrinfo`
`gethostbyname`	Removed in POSIX.1-2008	Not reentrant	`getnameinfo`
`getpagesize`	BSD API function not included in POSIX.1-2001	Portability issues.	`sysconf( _SC_PAGESIZE )`
`getpass`	Removed in POSIX.1-2001.	Not reentrant.	`getpwuid`
`getw`	Not present in POSIX.1-2001.		`fread`

Obsolete Function	Standards	Risk	Replacement Function
`getwd`	Marked legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`getcwd`
`index`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`strchr`
`makecontext`	Removed in POSIX.1-2008.	Portability issues.	Use POSIX thread instead.
`memalign`	Appears in SunOS 4.1.3. Not in 4.4 BSD or POSIX.1-2001		`posix_memalign`
`mktemp`	Removed in POSIX.1-2008.	Generated names are predictable and can cause a race condition.	`mkstemp` removes race risk
`pthread_attr_getstackaddr` and `pthread_attr_setstackaddr`		Ambiguities in the specification of the `stackaddr` attribute cause portability issues	`pthread_attr_getstack` and `pthread_attr_setstack`
`putw`	Not present in POSIX.1-2001.	Portability issues.	`fwrite`
`qecvt` and `qfcvt`	Marked as legacy in POSIX.1-2001, removed in POSIX.1-2008		`snprintf`
`qecvt_r` and `qfcvt_r`	Marked as legacy in POSIX.1-2001, removed in POSIX.1-2008		`snprintf`
`rand_r`	Marked as obsolete in POSIX.1-2008		
`re_comp`	BSD API function	Portability issues	`regcomp`
`re_exes`	BSD API function	Portability issues	`regexec`
`rindex`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`strrchr`

Obsolete Function	Standards	Risk	Replacement Function
`scalb`	Removed in POSIX.1-2008		`scalbln`, `scalblnf`, or `scalblnl`
`sigblock`	4.3BSD signal API whose origin is unclear		`sigprocmask`
`sigmask`	4.3BSD signal API whose origin is unclear		`sigprocmask`
`sigsetmask`	4.3BSD signal API whose origin is unclear		`sigprocmask`
`sigstack`	Interface is obsolete and not implemented on most platforms.	Portability issues.	`sigaltstack`
`sigvec`	4.3BSD signal API whose origin is unclear		`sigaction`
`swapcontext`	Removed in POSIX.1-2008	Portability issues.	Use POSIX threads.
`tmpnam` and `tmpnam_r`	Marked as obsolete in POSIX.1-2008.	This function generates a different string each time it is called, up to TMP_MAX times. If it is called more than TMP_MAX times, the behavior is implementation-defined.	`mkstemp`, `tmpfile`
`ttyslot`	Removed in POSIX.1-2001.		
`ualarm`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.	Errors are under-specified	`setitimer` or POSIX `timer_create`
`usleep`	Removed in POSIX.1-2008.		`nanosleep`
`utime`	SVr4, POSIX.1-2001. POSIX.1-2008 marks as obsolete.		

Obsolete Function	Standards	Risk	Replacement Function
`valloc`	Marked as obsolete in 4.3BSD. Marked as legacy in SUSv2. Removed from POSIX.1-2001		`posix_memalign`
`vfork`	Removed from POSIX.1-2008	Under-specified in previous standards.	`fork`
`wcswcs`	This function was not included in the final ISO/IEC 9899:1990/ Amendment 1:1995 (E).		`wcsstr`
`WinExec`	WinAPI provides this function only for 16-bit Windows compatibility.		`CreateProcess`
`LoadModule`	WinAPI provides this function only for 16-bit Windows compatibility.		`CreateProcess`

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Printing Out Time

```
#include <stdio.h>
#include <time.h>

void timecheck_bad(int argc, char *argv[])
{
    time_t ticks;

    ticks = time(NULL);
    printf("%.24s\r\n", ctime(&ticks));
}
```

In this example, the function `ctime` formats the current time and prints it out. However, `ctime` was removed after C99 because it does not work on multithreaded programs.

Correction — Different Time Function

One possible correction is to use `strftime` instead because this function uses a set buffer size.

```
#include <stdio.h>
#include <string.h>
#include <time.h>

void timecheck_good(int argc, char *argv[])
{
    char outBuff[1025];
    time_t ticks;
    struct tm * timeinfo;

    memset(outBuff, 0, sizeof(outBuff));

    ticks = time(NULL);
    timeinfo = localtime(&ticks);
    strftime(outBuff,sizeof(outBuff),"%I:%M%p.",timeinfo);
    fprintf(stdout, outBuff);
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `OBSOLETE_STD_FUNC`
Impact: Low
CWE ID: 474, 477

See Also

`Use of dangerous standard function` | `Unsafe standard function` | `Invalid use of standard library string routine`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Incorrect use of offsetof in C++

Incorrect arguments to `offsetof` macro causes undefined behavior

Description

Incorrect use of offsetof in C++ occurs when you pass arguments to the `offsetof` macro for which the behavior of the macro is not defined.

The `offsetof` macro:

```
offsetof(classType, aMember)
```

returns the offset in bytes of the data member `aMember` from the beginning of an object of type `classType`. For use in `offsetof`, `classType` and `aMember` have certain restrictions:

- `classType` must be a standard layout class.

  For instance, it must not have `virtual` member functions. For more information on the requirements for a standard layout class, see C++ named requirements: StandardLayoutType.
- `aMember` must not be static.
- `aMember` must not be a member function.

The checker flags uses of the `offsetof` macro where the arguments violate one or more of these restrictions.

Risk

Violating the restrictions on the arguments of the `offsetof` macro leads to undefined behavior.

Fix

Use the `offsetof` macro only on nonstatic data members of a standard layout class.

The result details state which restriction on the `offsetof` macro is violated. Fix the violation.

Examples

Use of `offsetof` Macro with Nonstandard Layout Class

```
#include <cstddef>

class myClass {
     int privateData;
  public:
     int publicData;
};

void func() {
  size_t off = offsetof(myClass, publicData);
  // ...
}
```

In this example, the class `myClass` has two data members with different access control, one private and the other public. Therefore, the class does not satisfy the requirements of a standard layout class and cannot be used with the `offsetof` macro.

Correction — Use Uniform Access Control for All Data Members

If the use of `offsetof` is important for the application, make sure that the first argument is a class with a standard layout. For instance, see if you can work around the need for a public data member.

```
#include <cstddef>

class myClass {
     int privateData;
     int publicData;
  public:
     int getpublicData(void) { return publicData;}
};

void func() {
  size_t off = offsetof(myClass, publicData);
```

```
  // ...
}
```

Result Information

Group: Programming
Language: C++
Default: On
Command-Line Syntax: `OFFSETOF_MISUSE`
Impact: Medium

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2019a

Possibly unintended evaluation of expression because of operator precedence rules

Operator precedence rules cause unexpected evaluation order in arithmetic expression

Description

Possibly unintended evaluation of expression because of operator precedence rules occurs when an arithmetic expression result is possibly unintended because operator precedence rules dictate an evaluation order that you do not expect.

The defect highlights expressions of the form `x` *`op_1`* `y` *`op_2`* `z`. Here, *`op_1`* and *`op_2`* are operator combinations that commonly induce this error. For instance, `x == y | z`.

The checker does not flag all operator combinations. For instance, `x == y || z` is not flagged because you most likely intended to perform a logical OR between `x == y` and `z`. Specifically, the checker flags these combinations:

- `&&` and `||`: For instance, `x || y && z` or `x && y || z`.
- Assignment and bitwise operations: For instance, `x = y | z`.
- Assignment and comparison operations: For instance, `x = y != z` or `x = y > z`.
- Comparison operations: For instance, `x > y > z` (except when one of the comparisons is an equality `x == y > z`).
- Shift and numerical operation: For instance, `x << y + 2`.
- Pointer dereference and arithmetic: For instance, `*p++`.

Risk

The defect can cause the following issues:

- If you or another code reviewer reviews the code, the intended order of evaluation is not immediately clear.
- It is possible that the result of the evaluation does not meet your expectations. For instance:

- In the operation *p++, it is possible that you expect the dereferenced value to be incremented. However, the pointer p is incremented before the dereference.
- In the operation (x == y | z), it is possible that you expect x to be compared with y | z. However, the == operation happens before the | operation.

Fix

See if the order of evaluation is what you intend. If not, apply parentheses to implement the evaluation order that you want.

For better readability of your code, it is good practice to apply parenthesis to implement an evaluation order even when operator precedence rules impose that order.

Examples

Expressions with Possibly Unintended Evaluation Order

```
int test(int a, int b, int c) {
    return(a & b == c);
}
```

In this example, the == operation happens first, followed by the & operation. If you intended the reverse order of operations, the result is not what you expect.

Correction — Parenthesis For Intended Order

One possible correction is to apply parenthesis to implement the intended evaluation order.

```
int test(int a, int b, int c) {
    return((a & b) == c);
}
```

Result Information

Group: Programming
Language: C | C++
Default: On

Command-Line Syntax: `OPERATOR_PRECEDENCE`
Impact: High
CWE ID: 783

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

External Websites

C++ Operator Precedence

Introduced in R2015b

Invalid use of standard library routine

Wrong arguments to standard library function

Description

Invalid use of standard library routine occurs when you use invalid arguments with a function from the standard library. This defect picks up errors related to other functions not covered by float, integer, memory, or string standard library routines.

Risk

Invalid arguments to a standard library function result in undefined behavior.

Fix

The fix depends on the root cause of the defect. For instance, the argument to a `printf` function can be `NULL` because a pointer was initialized with `NULL` and the initialization value was not overwritten along a specific execution path.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See "Address Polyspace Results Through Bug Fixes or Comments".

Examples

Calling `printf` Without a String

```
#include <stdio.h>
#include <stdlib.h>

void print_null(void) {

  printf(NULL);
}
```

The function `printf` takes only string input arguments or format specifiers. In this function, the input value is NULL, which is not a valid string.

Correction — Use Compatible Input Arguments

One possible correction is to change the input arguments to fit the requirements of the standard library routine. In this example, the input argument was changed to a character.

```
#include <stdio.h>

void print_null(void) {
    char zero_val = '0';
    printf((const char*)zero_val);
}
```

Check Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `OTHER_STD_LIB`
Impact: High
CWE ID: 227, 690

See Also

`Invalid use of standard library floating point routine` | `Invalid use of standard library integer routine` | `Invalid use of standard library memory routine` | `Invalid use of standard library string routine`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Array access out of bounds

Array index outside bounds during array access

Description

Array access out of bounds occurs when an array index falls outside the range `[0...array_size-1]` during array access.

Risk

Accessing an array outside its bounds is undefined behavior. You can read an unpredictable value or try to access a location that is not allowed and encounter a segmentation fault.

Fix

The fix depends on the root cause of the defect. For instance, you accessed an array inside a loop and one of these situations happened:

- The upper bound of the loop is too large.
- You used an array index that is the same as the loop index instead of being one less than the loop index.

To fix the issue, you have to modify the loop bound or the array index.

Another reason why an array index can exceed array bounds is a prior conversion from signed to unsigned integers. The conversion can result in a wrap around of the index value, eventually causing the array index to exceed the array bounds.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Array Access Out of Bounds Error

```
#include <stdio.h>

void fibonacci(void)
{
    int i;
    int fib[10];

    for (i = 0; i < 10; i++)
       {
        if (i < 2)
            fib[i] = 1;
         else
            fib[i] = fib[i-1] + fib[i-2];
       }

    printf("The 10-th Fibonacci number is %i .\n", fib[i]);
    /* Defect: Value of i is greater than allowed value of 9 */
}
```

The array `fib` is assigned a size of 10. An array index for `fib` has allowed values of `[0,1,2,...,9]`. The variable `i` has a value 10 when it comes out of the `for`-loop. Therefore, the `printf` statement attempts to access `fib[10]` through `i`.

Correction — Keep Array Index Within Array Bounds

One possible correction is to print `fib[i-1]` instead of `fib[i]` after the `for`-loop.

```
#include <stdio.h>

void fibonacci(void)
{
   int i;
   int fib[10];

   for (i = 0; i < 10; i++)
```

```
    {
        if (i < 2)
            fib[i] = 1;
        else
            fib[i] = fib[i-1] + fib[i-2];
    }

    /* Fix: Print fib[9] instead of fib[10] */
    printf("The 10-th Fibonacci number is %i .\n", fib[i-1]);
}
```

The `printf` statement accesses `fib[9]` instead of `fib[10]`.

Check Information

Group: Static memory
Language: C | C++
Default: On
Command-Line Syntax: `OUT_BOUND_ARRAY`
Impact: High
CWE ID: 119, 131, 466

See Also

`Pointer access out of bounds`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Pointer access out of bounds

Pointer dereferenced outside its bounds

Description

Pointer access out of bounds occurs when a pointer is dereferenced outside its bounds.

When a pointer is assigned an address, a block of memory is associated with the pointer. You cannot access memory beyond that block using the pointer.

Risk

Dereferencing a pointer outside its bounds is undefined behavior. You can read an unpredictable value or try to access a location that is not allowed and encounter a segmentation fault.

Fix

The fix depends on the root cause of the defect. For instance, you dereferenced a pointer inside a loop and one of these situations happened:

- The upper bound of the loop is too large.
- You used pointer arithmetic to advance the pointer with an incorrect value for the pointer increment.

To fix the issue, you have to modify the loop bound or the pointer increment value.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Pointer access out of bounds error

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
   {
    ptr++;
    *ptr=i;
    /* Defect: ptr out of bounds for i=9 */
   }

 return(arr);
}
```

`ptr` is assigned the address `arr` that points to a memory block of size `10*sizeof(int)`. In the `for`-loop, `ptr` is incremented 10 times. In the last iteration of the loop, `ptr` points outside the memory block assigned to it. Therefore, it cannot be dereferenced.

Correction — Check Pointer Stays Within Bounds

One possible correction is to reverse the order of increment and dereference of `ptr`.

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
     {
      /* Fix: Dereference pointer before increment */
      *ptr=i;
      ptr++;
     }

 return(arr);
}
```

After the last increment, even though `ptr` points outside the memory block assigned to it, it is not dereferenced more.

Check Information

Group: Static memory
Language: C | C++
Default: On
Command-Line Syntax: `OUT_BOUND_PTR`
Impact: High
CWE ID: 119, 131, 188, 466, 823

See Also

`Array access out of bounds`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Overlapping assignment

Memory overlap between left and right sides of an assignment

Description

Overlapping assignment occurs when there is a memory overlap between the left and right sides of an assignment. For instance, a variable is assigned to itself or one member of a union is assigned to another.

Risk

If the left and right sides of an assignment have memory overlap, the behavior is either redundant or undefined. For instance:

- Self-assignment such as `x=(int)(long)x;` is redundant unless `x` is `volatile`-qualified.
- Assignment of one union member to another causes undefined behavior.

  For instance, in the following code:

  - The result of the assignment `u1.a = u1.b` is undefined because `u1.b` is not initialized.
  - The result of the assignment `u2.b = u2.a` depends on the alignment and endianness of the implementation. It is not defined by C standards.

```
union {
   char a;
   int b;
}u1={'a'}, u2={'a'}; //'u1.a' and 'u2.a' are initialized

u1.a = u1.b;
u2.b = u2.a;
```

Fix

Avoid assignment between two variables that have overlapping memory.

Examples

Assignment of Union Members

```
#include <string.h>

union Data {
    int i;
    float f;
};

int main( ) {
    union Data data;
    data.i = 0;
    data.f = data.i;

    return 0;
}
```

In this example, the variables `data.i` and `data.f` are part of the same `union` and are stored in the same location. Therefore, part of their memory storage overlaps.

Result Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: `OVERLAPPING_ASSIGN`
Impact: Low
CWE ID: 665

See Also

`Copy of overlapping memory`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Copy of overlapping memory

Source and destination arguments of a copy function have overlapping memory

Description

Copy of overlapping memory occurs when there is a memory overlap between the source and destination argument of a copy function such as `memcpy` or `strcpy`. For instance, the source and destination arguments of `strcpy` are pointers to different elements in the same string.

Risk

If there is memory overlap between the source and destination arguments of copy functions, according to C standards, the behavior is undefined.

Fix

Determine if the memory overlap is what you want. If so, find an alternative function. For instance:

- If you are using `memcpy` to copy values from one memory location to another, use `memmove` instead of `memcpy`.
- If you are using `strcpy` to copy one string to another, use `memmove` instead of `strcpy`, as follows:

  ```
  s = strlen(source);
  memmove(destination, source, s + 1);
  ```

  `strlen` determines the string length without the null terminator. Therefore, you must move `s+1` bytes instead of `s` bytes.

Examples

Overlapping Copy

```
#include <string.h>

char str[] = {"ABCDEFGH"};

void my_copy() {
    strcpy(&str[0],(const char*)&str[2]);
}
```

In this example, because the source and destination argument are pointers to the same string `str`, there is memory overlap between their allowed buffers.

Result Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: `OVERLAPPING_COPY`
Impact: Medium
CWE ID: 475, 628, 687

See Also

`Overlapping assignment`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Information leak via structure padding

Padding bytes can contain sensitive information

Description

Information leak via structure padding occurs when you do not initialize the padding data of a structure or union before passing it across a trust boundary. A compiler adds padding bytes to the structure or union to ensure a proper memory alignment of its members. The bit-fields of the storage units can also have padding bits.

Information leak via structure padding raises a defect when:

- You call an untrusted function with structure or union pointer type argument containing uninitialized padding data.

  All external functions are considered untrusted.
- You copy or assign a structure or union containing uninitialized padding data to an untrusted object.

  All external structure or union objects, the output parameters of all externally linked functions, and the return pointer of all external functions are considered untrusted objects.

Risk

The padding bytes of the passed structure or union might contain sensitive information that an untrusted source can access.

Fix

- Prevent the addition of padding bytes for memory alignment by using the `pack` pragma or attribute supported by your compiler.
- Explicitly declare and initialize padding bytes as fields within the structure or union.
- Explicitly declare and initialize bit-fields corresponding to padding bits, even if you use the `pack` pragma or attribute supported by your compiler.

Examples

Structure with Padding Bytes Passed to External Function

```
#include <stddef.h>
#include <stdlib.h>
#include <string.h>

typedef struct s_padding
{
 /* Padding bytes may be introduced between
 * 'char c' and 'int i'
 */
        char c;
    int i;

/*Padding bits may be introduced around the bit-fields
* even if you use "#pragma pack" (Windows) or
* __attribute__((__packed__)) (GNU)*/

    unsigned int bf1:1;
    unsigned int bf2:2;
    unsigned char buffer[20];
} S_Padding ;



/* External function */
extern void copy_object(void *out, void *in, size_t s);

void func(void *out_buffer)
{
/*Padding bytes not initialized*/

    S_Padding s = {'A', 10, 1, 3, {}};
/*Structure passed to external function*/

    copy_object((void *)out_buffer, (void *)&s, sizeof(s));
}

void main(void)
{
    S_Padding s1;
```

```
    func(&s1);
}
```

In this example, structure `s1` can have padding bytes between the `char c` and `int i` members. The bit-fields of the storage units of the structure can also contain padding bits. The content of the padding bytes and bits is accessible to an untrusted source when `s1` is passed to `func`.

Correction — Use pack Pragma to Prevent Padding Bytes

One possible correction in Microsoft Visual Studio® is to use `#pragma pack()` to prevent padding bytes between the structure members. To prevent padding bits in the bit-fields of `s1`, explicitly declare and initialize the bit-fields even if you use `#pragma pack()`.

```
 #include <stddef.h>
#include <stdlib.h>
#include <string.h>
#include <limits.h>

#define CHAR_BIT 8

#pragma pack(push, 1)

typedef struct s_padding
{
/*No Padding bytes when you use "#pragma pack" (Windows) or
* __attribute__((__packed__)) (GNU)*/
    char c;
    int i;
    unsigned int bf1:1;
    unsigned int bf2:2;
/* Padding bits explicitely declared */
    unsigned int bf_filler : sizeof(unsigned) * CHAR_BIT - 3;
    unsigned char buffer[20];
}

    S_Padding;

#pragma pack(pop)


/* External function */
extern void copy_object(void *out, void *in, size_t s);
```

```
void func(void *out_buffer)
{
    S_Padding s = {'A', 10, 1, 3, 0 /* padding bits */, {}};
    copy_object((void *)out_buffer, (void *)&s, sizeof(s));
}

void main(void)
{
    S_Padding s1;
    func(&s1);
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: PADDING_INFO_LEAK
Impact: Low

See Also

Invalid assumptions about memory organization | Large pass-by-value argument | Memory comparison of padding data | Sensitive heap memory not cleared before release | Uncleared sensitive data in stack | Use of memset with size argument zero

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Partial override of overloaded virtual functions

Class overrides fraction of inherited virtual functions with a given name

Description

Partial override of overloaded virtual functions occurs when:

- A base class has multiple `virtual` methods with the same name but different signatures (overloading).
- A class derived from the base class overrides at least one of those `virtual` methods, but not all of them.

Risk

The `virtual` methods that the derived class does not override are hidden. You cannot call those methods using an object of the derived class.

Fix

See if the overloads in the base class are required. If they are needed, possible solutions include:

- In your derived class, if you override one `virtual` method, override all `virtual` methods from the base class with the same name as that method.
- Otherwise, add the line `using` *`Base_class_name`*`::`*`method_name`* to the derived class declaration. In this way, you can call the base class methods using an object of the derived class.

Examples

Partial Override

```
class Base {
public:
    explicit Base(int b);
    virtual ~Base() {};
    virtual void set()           {
        _b = (int)0;
    };
    virtual void set(short i)    {
        _b = (int)i;
    };
    virtual void set(int i)      {
        _b = (int)i;
    };
    virtual void set(long i)     {
        _b = (int)i;
    };
    virtual void set(float i)    {
        _b = (int)i;
    };
    virtual void set(double i)   {
        _b = (int)i;
    };
private:
    int _b;
};

class Derived: public Base {
        public:
                Derived(int b, int d): Base(b), _d(d) {};
                void set(int i)    { Base::set(i); _d = (int)i; };
        private:
                int _d;
};
```

In this example, the class `Derived` overrides the function `set` that takes an `int` argument. It does not override other functions that have the same name `set` but take arguments of other types.

The defect appears on the derived class name in the derived class definition. To find which base class method is overridden:

1. Navigate to the base class definition. On the **Source** pane, right-click the base class name and select **Go To Definition**.
2. In the base class definition, identify the method that has the same name and signature as a derived class method name.

Correction — Unhide Base Class Method

One possible correction is add the line `using Base::set` to the `Derived` class declaration.

```
class Base {
public:
    explicit Base(int b);
    virtual ~Base() {};
    virtual void set()           {
        _b = (int)0;
    };
    virtual void set(short i)    {
        _b = (int)i;
    };
    virtual void set(int i)      {
        _b = (int)i;
    };
    virtual void set(long i)     {
        _b = (int)i;
    };
    virtual void set(float i)    {
        _b = (int)i;
    };
    virtual void set(double i)   {
        _b = (int)i;
    };
private:
    int _b;
};

class Derived: public Base {
        public:
                Derived(int b, int d): Base(b), _d(d) {};
                using Base::set;
                void set(int i)    { Base::set(i); _d = (int)i; };
```

```
        private:
                int _d;
};
```

Result Information

Group: Object oriented
Language: C++
Default: On
Command-Line Syntax: `PARTIAL_OVERRIDE`
Impact: Medium

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Partially accessed array

Array partly read or written before end of scope

Description

Partially accessed array occurs when an array is partially read or written before the end of array scope. For arrays local to a function, the end of scope occurs when the function ends.

Risk

A partially accessed array often indicates an omission in coding. For instance, when sorting an array using a loop, you used a number of loop iterations such that one array element is never read. The implementation can result in an array that is not fully sorted.

Fix

The fix depends on the root cause of the defect. For instance, if the root cause is a loop with an incorrect number of iterations, change the loop bound or add a step after the loop to access the unread or unwritten elements.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Partially accessed array error

```
int Calc_Sum(void)
{
  int tab[5]={0,1,2,3,4},sum=0;
```

```
  /* Defect: tab[4] is not read */

  for (int i=0; i<4;i++) sum+=tab[i];

  return(sum);

 }
```

The array `tab` is only partially read before end of function `Calc_Sum`. While calculating `sum`, `tab[4]` is not included.

Correction — Access Every Array Element

One possible correction is to read every element in the array `tab`.

```
int Calc_Sum(void)
{
  int tab[5]={0,1,2,3,4},sum=0;

  /* Fix: Include tab[4] in calculating sum */
  for (int i=0; i<5;i++) sum+=tab[i];

  return(sum);

 }
```

Check Information

Group: Data flow
Language: C | C++
Default: On for handwritten code, off for generated code
Command-Line Syntax: `PARTIALLY_ACCESSED_ARRAY`
Impact: Low

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Large pass-by-value argument

Large argument passed by value between functions

Description

Large pass-by-value argument occurs when a large input argument or return value is passed between functions by its value.

Risk

Copy by value creates a copy of the argument in the function body. If the argument is large, its copy uses up a substantial part of the stack space available to the function. The copy can also increase the execution time significantly.

Special considerations for return values: In C code, when a function returns by value, the return value is copied to the caller. Therefore, this defect appears on functions that have large return values. In C++ code, if a function return value is of class type, under certain conditions, the standard allows compilers to avoid copying the return value (C++98: Section 12.8, Item 15; C++11: Section 12.8, Item 31). Most compilers do not perform a copy in such cases. This behavior is called return value optimization. In such cases, Polyspace Bug Finder does not produce this defect if a large object is returned by value.

Fix

For variables larger than 64 bytes, pass the value by pointer or by reference. For structured variables, you can also refactor the variable type so that only some of the members are copied.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Large Function Argument

```
typedef struct s_userid {
    char name[2];
    int idnumber[100];
} userid;

char username(userid first) {
    return first.name[0];
}
```

The large structure, `userid`, is passed to the function `username`. Because `userid` is larger than 64 bytes, this function produces a large pass-by-value defect.

Correction — Pass By Reference

One possible correction is to pass the argument by reference instead of by value. In this corrected example, the pointer to a `userid` structure is passed instead of the actual structure.

```
typedef struct s_userid {
    char name[2];
    int idnumber[100];
} userid;

char username(userid *first) {
    return (*first).name[0];
}
```

Large Function Return Value

```
#include <stdlib.h>

#define initialSize 4
#define idSize 100

typedef struct {
    char initials[initialSize];
    int id[idSize];
} userId;
```

```
userId* getAddress(void);
assignValues(char*, int*);

userId username(void) {
    userId * newId = getAddress();
    assignValues((*newId).initials, (*newId).id);
    return *newId;
}
```

In this example, the function `username` returns a large structure `*newId` by value. When a function calls `username`, the value in `*newId` is copied to the caller.

Correction — Pass By Reference

One possible correction is to return the large structure by reference. In this corrected example, the pointer to structure `newId` is returned from the function `username`.

```
#include <stdlib.h>

#define initialSize 4
#define idSize 100

typedef struct {
    char initials[initialSize];
    int id[idSize];
} userId;

userId* getAddress(void);
assignValues(char*, int*);

userId * username(void) {
    userId * newId = getAddress();
    assignValues((*newId).initials, (*newId).id);
    return newId;
}
```

Check Information

Group: Good practice
Language: C | C++
Default: Off
Command-Line Syntax: `PASS_BY_VALUE`

Impact: Low

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Use of path manipulation function without maximum sized buffer checking

Destination buffer of `getwd` or `realpath` is smaller than `PATH_MAX` bytes

Description

Use of path manipulation function without maximum-sized buffer checking occurs when the destination argument of a path manipulation function such as `realpath` or `getwd` has a buffer size less than `PATH_MAX` bytes.

Risk

A buffer smaller than `PATH_MAX` bytes can overflow but you cannot test the function return value to determine if an overflow occurred. If an overflow occurs, following the function call, the content of the buffer is undefined.

For instance, `char *getwd(char *buf)` copies an absolute path name of the current folder to its argument. If the length of the absolute path name is greater than `PATH_MAX` bytes, `getwd` returns `NULL` and the content of `*buf` is undefined. You can test the return value of `getwd` for `NULL` to see if the function call succeeded.

However, if the allowed buffer for `buf` is less than `PATH_MAX` bytes, a failure can occur for a smaller absolute path name. In this case, `getwd` does not return `NULL` even though a failure occurred. Therefore, the allowed buffer for `buf` must be `PATH_MAX` bytes long.

Fix

Possible fixes are:

- Use a buffer size of `PATH_MAX` bytes. If you obtain the buffer from an unknown source, before using the buffer as argument of `getwd` or `realpath` function, make sure that the size is less than `PATH_MAX` bytes.
- Use a path manipulation function that allows you to specify a buffer size.

For instance, if you are using `getwd` to get the absolute path name of the current folder, use `char *getcwd(char *buf, size_t size);` instead. The additional argument `size` allows you to specify a size greater than or equal to `PATH_MAX`.

- Allow the function to allocate additional memory dynamically, if possible.

  For instance, `char *realpath(const char *path, char *resolved_path);` dynamically allocates memory if `resolved_path` is `NULL`. However, you have to deallocate this memory later using the `free` function.

Examples

Possible Buffer Overflow in Use of `getwd` Function

```
#include <unistd.h>
#include <linux/limits.h>
#include <stdio.h>

void func(void) {
    char buf[PATH_MAX];
    if (getwd(buf+1)!= NULL)         {
        printf("cwd is %s\n", buf);
    }
}
```

In this example, although the array `buf` has `PATH_MAX` bytes, the argument of `getwd` is `buf + 1`, whose allowed buffer is less than `PATH_MAX` bytes.

Correction — Use Array of Size `PATH_MAX` Bytes

One possible correction is to use an array argument with size equal to `PATH_MAX` bytes.

```
#include <unistd.h>
#include <linux/limits.h>
#include <stdio.h>

void func(void) {
    char buf[PATH_MAX];
    if (getwd(buf)!= NULL)         {
        printf("cwd is %s\n", buf);
    }
}
```

Result Information

Group: Static memory
Language: C | C++
Default: Off
Command-Line Syntax: PATH_BUFFER_OVERFLOW
Impact: High
CWE ID: 785

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Vulnerable path manipulation

Path argument with `/../`, `/abs/path/`, or other unsecure elements

Description

Vulnerable path manipulation detects relative or absolute path traversals. If the path traversal contains a tainted source, or you use the path to open/create files, Bug Finder raises a defect.

Risk

Relative path elements, such as `".."` can resolve to locations outside the intended folder. Absolute path elements, such as `"/abs/path"` can also resolve to locations outside the intended folder.

An attacker can use these types of path traversal elements to traverse to the rest of the file system and access other files or folders.

Fix

Avoid vulnerable path traversal elements such as `/../` and `/abs/path/`. Use fixed file names and locations wherever possible.

Examples

Relative Path Traversal

```
# include <stdio.h>
# include <string.h>
# include <wchar.h>
# include <sys/types.h>
# include <sys/stat.h>
# include <fcntl.h>
# include <unistd.h>
# include <stdlib.h>
```

```
# define BASEPATH "/tmp/"
# define FILENAME_MAX 512

static void Relative_Path_Traversal(void)
{
    char * data;
    char data_buf[FILENAME_MAX] = BASEPATH;
    char sub_buf[FILENAME_MAX];

    if (fgets(sub_buf, FILENAME_MAX, stdin) == NULL) exit (1);
    data = data_buf;
    strcat(data, sub_buf);

    FILE *file = NULL;
    file = fopen(data, "wb+");
    if (file != NULL) fclose(file);
}

int path_call(void){
    Relative_Path_Traversal();
}
```

This example opens a file from `"/tmp/"`, but uses a relative path to the file. An external user can manipulate this relative path when `fopen` opens the file.

Correction — Use Fixed File Name

One possible correction is to use a fixed file name instead of a relative path. This example uses `file.txt`.

```
# include <stdio.h>
# include <string.h>
# include <wchar.h>
# include <sys/types.h>
# include <sys/stat.h>
# include <fcntl.h>
# include <unistd.h>
# include <stdlib.h>
# define BASEPATH "/tmp/"
# define FILENAME_MAX 512

static void Relative_Path_Traversal(void)
{
    char * data;
    char data_buf[FILENAME_MAX] = BASEPATH;
```

```
    data = data_buf;

    /* FIX: Use a fixed file name */
    strcat(data, "file.txt");
    FILE *file = NULL;
    file = fopen(data, "wb+");
    if (file != NULL) fclose(file);
}

int path_call(void){
    Relative_Path_Traversal();
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: PATH_TRAVERSAL
Impact: Low
CWE ID: 22, 23, 36

See Also

`Use of path manipulation function without maximum sized buffer checking`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Preprocessor directive in macro argument

You use a preprocessor directive in the argument to a function-like macro

Description

Preprocessor directive in macro argument occurs when you use a preprocessor directive in the argument to a function-like macro or a function that might be implemented as a function-like macro.

For instance, a `#ifdef` statement occurs in the argument to a `memcpy` function. The `memcpy` function might be implemented as a macro.

```
memcpy(dest, src,
    #ifdef PLATFORM1
      12
    #else
      24
    #endif
  );
```

The checker flags similar usage in `printf` and `assert`, which can also be implemented as macros.

Risk

During preprocessing, a function-like macro call is replaced by the macro body and the parameters are replaced by the arguments to the macro call (argument substitution). Suppose a macro `min()` is defined as follows.

```
#define min(X, Y)  ((X) < (Y) ? (X) : (Y))
```

When you call `min(1,2)`, it is replaced by the body `((X) < (Y) ? (X) : (Y))`. `X` and `Y` are replaced by 1 and 2.

According to the C11 Standard (Sec. 6.10.3), if the list of arguments to a function-like macro itself has preprocessing directives, the argument substitution during preprocessing is undefined.

Fix

To ensure that the argument substitution happens in an unambiguous manner, use the preprocessor directives outside the function-like macro.

For instance, to execute `memcpy` with different arguments based on a `#ifdef` directive, call `memcpy` multiple times within the `#ifdef` directive branches.

```
#ifdef PLATFORM1
    memcpy(dest, src, 12);
#else
    memcpy(dest, src, 24);
#endif
```

Examples

Directives in Function-Like Macros

```
#include <stdio.h>

#define print(A) printf(#A)

void func(void) {
    print(
#ifdef SW
          "Message 1"
#else
          "Message 2"
#endif
         );
}
```

In this example, the preprocessor directives `#ifdef` and `#endif` occur in the argument to the function-like macro `print()`.

Correction — Use Directives Outside Macro

One possible correction is to use the function-like macro multiple times in the branches of the `#ifdef` directive.

```
#include <stdio.h>
```

```
#define print(A) printf(#A)

void func(void) {
#ifdef SW
        print("Message 1");
#else
        print("Message 2");
#endif
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: PRE_DIRECTIVE_MACRO_ARG
Impact: Low

See Also

MISRA C:2012 Rule 20.6

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Universal character name from token concatenation

You create a universal character name by joining tokens with ## operator

Description

Universal character name from token concatenation occurs when two preprocessing tokens joined with a ## operator create a universal character name. A universal character name begins with `\u` or `\U` followed by hexadecimal digits. It represents a character not found in the basic character set.

For instance, you form the character `\u0401` by joining two tokens:

```
#define assign(uc1, uc2, val) uc1##uc2 = val
...
assign(\u04, 01, 4);
```

Risk

The C11 Standard (Sec. 5.1.1.2) states that if a universal character name is formed by token concatenation, the behavior is undefined.

Fix

Use the universal character name directly instead of producing it through token concatenation.

Examples

Universal Character Name from Token Concatenation

```
#define assign(uc1, uc2, val) uc1##uc2 = val

int func(void) {
```

```
    int \u0401 = 0;
    assign(\u04, 01, 4);
    return \u0401;
}
```

In this example, the `assign` macro, when expanded, joins the two tokens `\u04` and `01` to form the universal character name `\u0401`.

Correction — Use Universal Character Name Directly

One possible correction is to use the universal character name `\u0401` directly. The correction redefines the `assign` macro so that it does not join tokens.

```
#define assign(ucn, val) ucn = val

int func(void) {
    int \u0401 = 0;
    assign(\u0401, 4);
    return \u0401;
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `PRE_UCNAME_JOIN_TOKENS`
Impact: Low

See Also

`MISRA C:2012 Rule 20.10`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Unreliable cast of pointer

Pointer implicitly cast to different data type

Description

Unreliable cast of pointer occurs when a pointer is implicitly cast to a data type different from its declaration type. Such an implicit casting can take place, for instance, when a pointer to data type `char` is assigned the address of an integer.

This defect applies only if the code language for the project is C.

Risk

Casting a pointer to data type different from its declaration type can result in issues such as buffer overflow. If the cast is implicit, it can indicate a coding error.

Fix

Avoid *implicit* cast of a pointer to a data type different from its declaration type.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Unreliable cast of pointer error

```
#include <string.h>

void Copy_Integer_To_String()
{
 int src[]={1,2,3,4,5,6,7,8,9,10};
 char buffer[]="Buffer_Text";
```

```
 strcpy(buffer,src);
 /* Defect: Implicit cast of (int*) to (char*) */
}
```

`src` is declared as an `int*` pointer. The `strcpy` statement, while copying to `buffer`, implicitly casts `src` to `char*`.

Correction — Avoid Pointer Cast

One possible correction is to declare the pointer `src` with the same data type as `buffer`.

```
#include <string.h>
 void Copy_Integer_To_String()
{
 /* Fix: Declare src with same type as buffer */
 char *src[10]={"1","2","3","4","5","6","7","8","9","10"};
 char *buffer[10];

 for(int i=0;i<10;i++)
   buffer[i]="Buffer_Text";

 for(int i=0;i<10;i++)
   buffer[i]= src[i];
 }
```

Check Information

Group: Static memory
Language: C
Default: On
Command-Line Syntax: PTR_CAST
Impact: Medium
CWE ID: 135, 704, 843

See Also

`Unreliable cast of function pointer`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Wrong type used in sizeof

`sizeof` argument does not match pointed type

Description

Wrong type used in sizeof occurs when both of the following conditions hold:

- You assign the address of a block of memory to a pointer, or transfer data between two blocks of memory. The assignment or copy uses the `sizeof` operator.

  For instance, you initialize a pointer using `malloc(sizeof(`*`type`*`))` or copy data between two addresses using `memcpy(`*`destination_ptr`*`, `*`source_ptr`*`, sizeof(`*`type`*`))`.
- You use an incorrect type as argument of the `sizeof` operator. You use the pointer type instead of the type that the pointer points to.

  For instance, to initialize a *`type`*`*` pointer, you use `malloc(sizeof(`*`type`*`*))` instead of `malloc(sizeof(`*`type`*`))`.

Risk

Irrespective of what *`type`* stands for, the expression `sizeof(`*`type`*`*)` always returns a fixed size. The size returned is the pointer size on your platform in bytes. The appearance of `sizeof(`*`type`*`*)` often indicates an unintended usage. The error can cause allocation of a memory block that is much smaller than what you need and lead to weaknesses such as buffer overflows.

For instance, assume that `structType` is a structure with ten `int` variables. If you initialize a `structType*` pointer using `malloc(sizeof(structType*))` on a 32-bit platform, the pointer is assigned a memory block of four bytes. However, to be allocated completely for one `structType` variable, the `structType*` pointer must point to a memory block of `sizeof(structType) = 10 * sizeof(int)` bytes. The required size is much greater than the actual allocated size of four bytes.

Fix

To initialize a *type** pointer, replace `sizeof(`*type*`*)` in your pointer initialization expression with `sizeof(`*type*`)`.

Examples

Allocate a Char Array With `sizeof`

```
#include <stdlib.h>

void test_case_1(void) {
    char* str;

    str = (char*)malloc(sizeof(char*) * 5);
    free(str);

}
```

In this example, memory is allocated for the character pointer `str` using a `malloc` of five char pointers. However, `str` is a pointer to a character, not a pointer to a character pointer. Therefore the `sizeof` argument, `char*`, is incorrect.

Correction — Match Pointer Type to `sizeof` Argument

One possible correction is to match the argument to the pointer type. In this example, `str` is a character pointer, therefore the argument must also be a character.

```
#include <stdlib.h>

void test_case_1(void) {
    char* str;

    str = (char*)malloc(sizeof(char) * 5);
    free(str);

}
```

Check Information

Group: Programming
Language: C | C++
Default: On for handwritten code, off for generated code
Command-Line Syntax: `PTR_SIZEOF_MISMATCH`
Impact: High
CWE ID: 467

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Subtraction or comparison between pointers to different arrays

Subtraction or comparison between pointers causes undefined behavior

Description

Subtraction or comparison between pointers to different arrays occurs when you subtract or compare pointers that are null or that point to elements in different arrays. The relational operators for the comparison are >, <, >=, and <=.

Risk

When you subtract two pointers to elements in the same array, the result is the difference between the subscripts of the two array elements. Similarly, when you compare two pointers to array elements, the result is the positions of the pointers relative to each other. If the pointers are null or point to different arrays, a subtraction or comparison operation is undefined. If you use the subtraction result as a buffer index, it can cause a buffer overflow.

Fix

Before you subtract or use relational operators to compare pointers to array elements, check that they are non-null and that they point to the same array.

Examples

Subtraction Between Pointers to Elements in Different Arrays

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define SIZE20 20
```

```
size_t func(void)
{
    int nums[SIZE20];
    int end;
    int *next_num_ptr = nums;
    size_t free_elements;
    /* Increment next_num_ptr as array fills */

    /* Subtraction operation is undefined unless array nums
    is adjacent to variable end in memory. */
    free_elements = &end - next_num_ptr;
    return free_elements;
}
```

In this example, the array `nums` is incrementally filled. Pointer subtraction is then used to determine how many free elements remain. Unless `end` points to a memory location one past the last element of `nums`, the subtraction operation is undefined.

Correction — Subtract Pointers to the Same Array

Subtract the pointer to the last element that was filled from the pointer to the last element in the array.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define SIZE20 20

size_t func(void)
{
    int nums[SIZE20];
    int *next_num_ptr = nums;
    size_t free_elements;
    /* Increment next_num_ptr as array fills */

    /* Subtraction operation involves pointers to the same array. */
    free_elements = &(nums[SIZE20 - 1]) - next_num_ptr;

    return free_elements + 1;
}
```

Result Information

Group: Static memory
Language: C | C++
Default: On
Command-Line Syntax: `PTR_TO_DIFF_ARRAY`
Impact: High
CWE ID: 469

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Use of automatic variable as putenv-family function argument

putenv-family function argument not accessible outside its scope

Description

Use of automatic variable as `putenv`-family function argument occurs when the argument of a `putenv`-family function is a local variable with automatic duration.

Risk

The function `putenv(char *string)` inserts a pointer to its supplied argument into the environment array, instead of making a copy of the argument. If the argument is an automatic variable, its memory can be overwritten after the function containing the `putenv()` call returns. A subsequent call to `getenv()` from another function returns the address of an out-of-scope variable that cannot be dereferenced legally. This out-of-scope variable can cause environment variables to take on unexpected values, cause the program to stop responding, or allow arbitrary code execution vulnerabilities.

Fix

Use `setenv()`/`unsetenv()` to set and unset environment variables. Alternatively, use `putenv`-family function arguments with dynamically allocated memory, or, if your application has no reentrancy requirements, arguments with static duration. For example, a single thread execution with no recursion or interrupts does not require reentrancy. It cannot be called (reentered) during its execution.

Examples

Automatic Variable as Argument of `putenv()`

```
#include <stdio.h>
#include <stdlib.h>
```

```
#include <string.h>

#define SIZE1024 1024

void func(int var)
{
    char env[SIZE1024];
    int retval = sprintf(env, "TEST=%s", var ? "1" : "0");
    if (retval <= 0) {
        /* Handle error */
    }
    /* Environment variable TEST is set using putenv().
    The argument passed to putenv is an automatic variable. */
    retval = putenv(env);
    if (retval != 0) {
        /* Handle error */
    }
}
```

In this example, `sprintf()` stores the character string `TEST=var` in `env`. The value of the environment variable `TEST` is then set to `var` by using `putenv()`. Because `env` is an automatic variable, the value of `TEST` can change once `func()` returns.

Correction — Use `static` Variable for Argument of `putenv()`

Declare `env` as a static-duration variable. The memory location of `env` is not overwritten for the duration of the program, even after `func()` returns.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define SIZE1024 1024
void func(int var)
{
    /* static duration variable */
    static char env[SIZE1024];
    int retval = sprintf(env,"TEST=%s", var ? "1" : "0");
    if (retval <= 0) {
        /* Handle error */
    }

    /* Environment variable TEST is set using putenv() */
```

```
    retval=putenv(env);
    if (retval != 0) {
        /* Handle error */
    }
}
```

Correction — Use `setenv()` to Set Environment Variable Value

To set the value of `TEST` to `var`, use `setenv()`.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define SIZE1024 1024

void func(int var)
{
    /* Environment variable TEST is set using setenv() */
    int retval = setenv("TEST", var ? "1" : "0", 1);

    if (retval != 0) {
        /* Handle error */
    }
}
```

Result Information

Group: Static memory
Language: C | C++
Default: On
Command-Line Syntax: `PUTENV_AUTO_VAR`
Impact: High
CWE ID: 562, 686, 825

See Also

`Pointer or reference to stack variable leaving scope`

Topics

“Interpret Polyspace Bug Finder Access Results”

“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Qualifier removed in conversion

Variable qualifier is lost during conversion

Description

Qualifier removed in conversion occurs during a pointer conversion when one pointer has a qualifier and the other does not. For example, when converting from a `const int*` to an `int*`, the conversion removes the `const` qualifier.

This defect applies only for projects in C.

Risk

Qualifiers such as `const` or `volatile` in a pointer declaration:

```
const int* ptr;
```

imply that the underlying object is `const` or `volatile`. These qualifiers act as instructions to the compiler. For instance, a `const` object is not supposed to be modified in the code and a `volatile` object is not supposed to be optimized away by the compiler.

If a second pointer points to the same object but does not use the same qualifier, the qualifier on the first pointer is no longer valid. For instance, if a `const int*` pointer and an `int*` pointer point to the same object, you can modify the object through the second pointer and violate the contract implied by the `const` qualifier in the first pointer.

Fix

If you intend to convert from one pointer to another, declare both pointers with the same qualifiers.

Examples

Cast of Character Pointers

```
void implicit_cast(void) {
    const char  cc, *pcc = &cc;
    char * quo;

    quo = &cc;
    quo = pcc;

    read(quo);
}
```

During the assignment to the character `q`, the variables, `cc` and `pcc`, are converted from `const char` to `char`. The `const` qualifier is removed during the conversion causing a defect.

Correction — Add Qualifiers

One possible correction is to add the same qualifiers to the new variables. In this example, changing `q` to a `const char` fixes the defect.

```
void implicit_cast(void) {
    const char  cc, *pcc = &cc;
    const char * quo;

    quo = &cc;
    quo = pcc;

    read(quo);
}
```

Correction — Remove Qualifiers

One possible correction is to remove the qualifiers in the converted variable. In this example, removing the `const` qualifier from the `cc` and `pcc` initialization fixes the defect.

```
void implicit_basic_cast(void) {
    char  cc, *pcc = &cc;
    char * quo;

    quo = &cc;
```

```
    quo = pcc;

    read(quo);
}
```

Check Information

Group: Programming
Language: C
Default: Off
Command-Line Syntax: `QUALIFIER_MISMATCH`
Impact: Low
CWE ID: 704

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Deterministic random output from constant seed

Seeding routine uses a constant seed making the output deterministic

Description

Deterministic random output from constant seed detects random standard functions that when given a constant seed, have deterministic output.

Risk

When some random functions, such as `srand`, `srandom`, and `initstate`, have constant seeds, the results produce the same output every time that your program is run. A hacker can disrupt your program if they know how your program behaves.

Fix

Use a different random standard function or use a nonconstant seed.

Some standard random routines are inherently cryptographically weak on page 1-885, and should not be used for security purposes.

Examples

Random Number Generator Initialization

```
#include <stdlib.h>

void random_num(void)
{
    srand(12345U);
    /* ... */
}
```

This example initializes a random number generator using `srand` with a constant seed. The random number generation is deterministic, making this function cryptographically weak.

Correction — Use Different Random Number Generator

One possible correction is to use a random number generator that does not require a seed. This example uses `rand_s`.

```
#define _CRT_RAND_S
#include <stdlib.h>
#include <stdio.h>

unsigned int random_num_time(void)
{

    unsigned int number;
    errno_t err;
    err = rand_s(&number);

    if(err != 0)
    {
        return number;
    }
    else
    {
        return err;
    }
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `RAND_SEED_CONSTANT`
Impact: Medium
CWE ID: 330, 336

See Also

`Predictable random output from predictable seed` | `Unsafe standard encryption function` | `Vulnerable pseudo-random number generator`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Predictable random output from predictable seed

Seeding routine uses a predictable seed making the output predictable

Description

Predictable random output from predictable seed looks for random standard functions that use a nonconstant but predictable seed. Examples of predictable seed generators are `time`, `gettimeofday`, and `getpid`.

Risk

When you use predictable seed values for random number generation, your random numbers are also predictable. A hacker can disrupt your program if they know how your program behaves.

Fix

You can use a different function to generate less predictable seeds.

You can also use a different random number generator that does not require a seed. For example, the Windows API function `rand_s` seeds itself by default. It uses information from the entire system, for example, system time, thread ids, system counter, and memory clusters. This information is more random and a user cannot access this information.

Some standard random routines are inherently cryptographically weak on page 1-885, and should not be used for security purposes.

Examples

Seed as an Argument

```
#include <stdlib.h>
#include <time.h>
```

```
void seed_rng(int seed)
{
    srand(seed);
}

int generate_num(void)
{
    seed_rng(time(NULL) + 3);
    /* ... */
}
```

This example uses `srand` to start the random number generator with `seed` as the seed. However, `seed` is predictable because the function `time` generates it. So, an attacker can predict the random numbers generated by `srand`.

Correction — Use Different Random Number Generator

One possible correction is to use a random number generator that does not require a seed. This example uses `rand_s`.

```
#define _CRT_RAND_S

#include <stdlib.h>
#include <stdio.h>
#include <errno.h>

int generate_num(void)
{
    unsigned int number;
    errno_t err;
    err = rand_s(&number);

    if(err != 0)
    {
        return number;
    }
    else
    {
        return err;
    }
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `RAND_SEED_PREDICTABLE`
Impact: Medium
CWE ID: 330, 337

See Also

`Deterministic random output from constant seed` | `Unsafe standard encryption function` | `Vulnerable pseudo-random number generator`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Writing to read-only resource

File initially opened as read only is modified

Description

Writing to read-only resource occurs when you attempt to write to a file that you have opened earlier in read-only mode.

For instance, you open a file using `fopen` with the access mode argument `r`. You write to that file with a function in the `fprintf` family.

Risk

Writing to a read-only file causes undefined behavior.

Fix

If you want to write to the file, open the file in a mode that is suitable for writing.

Examples

Writing to Read-Only File

```
#include <stdio.h>

void func(void) {
    FILE* fp ;

    fp = fopen("file.txt", "r");
    fprintf(fp, "Some data");
    fclose(fp);
}
```

In this example, the file `file.txt` is opened in read-only mode. When the `FILE` pointer associated with `file.txt` is used as an argument of `fprintf`, a **Writing to read-only resource** defect occurs.

Correction — Open File as Writable

One possible correction is to use the access specifier `"a"` instead of `"r"`. `file.txt` is now open for output at the end of the file.

```
#include <stdio.h>

void func(void) {
    FILE* fp ;

    fp = fopen("file.txt", "a");
    fprintf(fp, "Some data");
    fclose(fp);
}
```

Result Information

Group: Resource management
Language: C | C++
Default: On
Command-Line Syntax: `READ_ONLY_RESOURCE_WRITE`
Impact: High

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Misuse of readlink()

Third argument of `readlink` does not leave space for null terminator in buffer

Description

Misuse of readlink() occurs when you pass a buffer size argument to `readlink()` that does not leave space for a null terminator in the buffer.

For instance:

```
ssize_t len = readlink("/usr/bin/perl", buf, sizeof(buf));
```

The third argument is exactly equal to the size of the second argument. For large enough symbolic links, this use of `readlink()` does not leave space to enter a null terminator.

Risk

The `readlink()` function copies the content of a symbolic link (first argument) to a buffer (second argument). However, the function does not append a null terminator to the copied content. After using `readlink()`, you must explicitly add a null terminator to the buffer.

If you fill the entire buffer when using `readlink`, you do not leave space for this null terminator.

Fix

When using the `readlink()` function, make sure that the third argument is one less than the buffer size.

Then, append a null terminator to the buffer. To determine where to add the null terminator, check the return value of `readlink()`. If the return value is -1, an error has occurred. Otherwise, the return value is the number of characters (bytes) copied.

Examples

Incorrect Size Argument of `readlink`

```
#include <unistd.h>

#define SIZE1024 1024

extern void display_path(const char *);

void func() {
    char buf[SIZE1024];
    ssize_t len = readlink("/usr/bin/perl", buf, sizeof(buf));
    if (len > 0) {
        buf[len - 1] = '\0';
    }
    display_path(buf);
}
```

In this example, the third argument of `readlink` is exactly the size of the buffer (second argument). If the first argument is long enough, this use of `readlink` does not leave space for the null terminator.

Also, if no characters are copied, the return value of `readlink` is 0. The following statement leads to a buffer underflow when `len` is 0.

```
buf[len - 1] = '\0';
```

Correction — Make Sure Size Argument is One Less Than Buffer Size

One possible correction is to make sure that the third argument of `readlink` is one less than size of the second argument.

The following corrected code also accounts for `readlink` returning 0.

```
#include <stdlib.h>
#include <unistd.h>

#define fatal_error() abort()
#define SIZE1024 1024

extern void display_path(const char *);
```

```
void func() {
    char buf[SIZE1024];
    ssize_t len = readlink("/usr/bin/perl", buf, sizeof(buf) - 1);
    if (len != -1) {
        buf[len] = '\0';
        display_path(buf);
    }
    else {
        /* Handle error */
        fatal_error();
    }
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: READLINK_MISUSE
Impact: Medium
CWE ID: 170

See Also

Array access out of bounds | File access between time of check and use (TOCTOU) | Invalid use of standard library string routine | Pointer access out of bounds | Returned value of a sensitive function not checked

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017a

Execution of a binary from a relative path can be controlled by an external actor

Command with relative path is vulnerable to malicious attack

Description

Execution of a binary from a relative path can be controlled by an external actor detects calls to an external command. If the call uses a relative path or no path to call the external command, Bug Finder flags the call as a defect.

This defect also finds results that the **Execution of externally controlled command** defect checker finds.

Risk

By using a relative path or no path to call an external command, your program uses an unsafe search process to find the command. An attacker can control the search process and replace the intended command with a command of their own.

Fix

When you call an external command, specify the full path.

Examples

Call Command with Relative Path

```
# define _GNU_SOURCE
# include <sys/types.h>
# include <sys/socket.h>
# include <unistd.h>
# include <stdio.h>
# include <stdlib.h>
# include <wchar.h>
```

```
# include <string.h>
# define MAX_BUFFER 100

void rel_path()
{
    char * data;
    char data_buf[MAX_BUFFER] = "";
    data = data_buf;

    strcpy(data, "ls -la");
    FILE *pipe;
    pipe = popen(data, "wb");
    if (pipe != NULL) pclose(pipe);
}
```

In this example, Bug Finder flags `popen` because it tries to call `ls -la` using a relative path. An attacker can manipulate the command to use a malicious version.

Correction — Use Full Path

One possible correction is to use the full path when calling the command.

```
# define _GNU_SOURCE
# include <sys/types.h>
# include <sys/socket.h>
# include <unistd.h>
# include <stdio.h>
# include <stdlib.h>
# include <wchar.h>
# include <string.h>
# define MAX_BUFFER 100

void rel_path()
{
    char * data;
    char data_buf[MAX_BUFFER] = "";
    data = data_buf;

    strcpy(data, "/usr/bin/ls -la");
    FILE *pipe;
    pipe = popen(data, "wb");
    if (pipe != NULL) pclose(pipe);
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `RELATIVE_PATH_CMD`
Impact: Medium
CWE ID: 114, 427

See Also

`Load of library from a relative path can be controlled by an external actor` | `Vulnerable path manipulation` | `Execution of externally controlled command` | `Command executed from externally controlled path`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Load of library from a relative path can be controlled by an external actor

Library loaded with relative path is vulnerable to malicious attacks

Description

Load of library from a relative path can be controlled by an external actor detects library loading routines that load an external library. If you load the library using a relative path or no path, Bug Finder flags the loading routine as a defect.

Risk

By using a relative path or no path to load an external library, your program uses an unsafe search process to find the library. An attacker can control the search process and replace the intended library with a library of their own.

Fix

When you load an external library, specify the full path.

Examples

Open Library with Library Name

```
#include <dlfcn.h>
#include <stdlib.h>
#include <string.h>
#include <malloc.h>
#include <stdio.h>

void relative_path()
{
    dlopen("liberty.dll",RTLD_LAZY);
}
```

In this example, `dlopen` opens the `liberty` library by calling only the name of the library. However, this call to the library uses a relative path to find the library, which is unsafe.

Correction — Use Full Path to Library

One possible correction is to use the full path to the library when you load it into your program.

```
#include <dlfcn.h>
#include <stdlib.h>
#include <string.h>
#include <malloc.h>
#include <stdio.h>

void relative_path()
{
    dlopen("/home/my_libs/library/liberty.dll",RTLD_LAZY);
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `RELATIVE_PATH_LIB`
Impact: Medium
CWE ID: 114, 427

See Also

`Execution of a binary from a relative path can be controlled by an external actor` | `Vulnerable path manipulation` | `Library loaded from externally controlled path`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Resource leak

File stream not closed before `FILE` pointer scope ends or pointer is reassigned

Description

Resource leak occurs when you open a file stream by using a `FILE` pointer but do not close it before:

- The end of the pointer's scope.
- Assigning the pointer to another stream.

Risk

If you do not release file handles explicitly as soon as possible, a failure can occur due to exhaustion of resources.

Fix

Close a `FILE` pointer before the end of its scope, or before you assign the pointer to another stream.

Examples

`FILE` Pointer Not Released Before End of Scope

```
#include <stdio.h>

void func1( void ) {
    FILE *fp1;
    fp1 = fopen ( "data1.txt", "w" );
    fprintf ( fp1, "*" );

    fp1 = fopen ( "data2.txt", "w" );
    fprintf ( fp1, "!" );
```

```
    fclose ( fp1 );
}
```

In this example, the file pointer `fp1` is pointing to a file `data1.txt`. Before `fp1` is explicitly dissociated from the file stream of `data1.txt`, it is used to access another file `data2.txt`.

Correction — Release FILE Pointer

One possible correction is to explicitly dissociate `fp1` from the file stream of `data1.txt`.

```
#include <stdio.h>

void func1( void ) {
    FILE *fp1;
    fp1 = fopen ( "data1.txt", "w" );
    fprintf ( fp1, "*" );
    fclose(fp1);

    fp1 = fopen ( "data2.txt", "w" );
    fprintf ( fp1, "!" );
    fclose ( fp1 );
}
```

Result Information

Group: Resource management
Language: C | C++
Default: On
Command-Line Syntax: `RESOURCE_LEAK`
Impact: High
CWE ID: 772

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Returned value of a sensitive function not checked

Sensitive functions called without checking for unexpected return values and errors

Description

Returned value of a sensitive function not checked occurs when you call sensitive standard functions, but you:

- Ignore the return value.
- Use an output or a return value without testing the validity of the return value.

For this defect, two type of functions are considered: ***sensitive*** and ***critical sensitive***.

A ***sensitive*** function is a standard function that can encounter:

- Exhausted system resources (for example, when allocating resources)
- Changed privileges or permissions
- Tainted sources when reading, writing, or converting data from external sources
- Unsupported features despite an existing API

A ***critical sensitive*** function is a sensitive function that performs one of these critical or vulnerable tasks:

- Set privileges (for example, `setuid`)
- Create a jail (for example, `chroot`)
- Create a process (for example, `fork`)
- Create a thread (for example, `pthread_create`)
- Lock or unlock mutex (for example, `pthread_mutex_lock`)
- Lock or unlock memory segments (for example, `mlock`)

Risk

If you do not check the return value of functions that perform sensitive or critical sensitive tasks, your program can behave unexpectedly. Errors from these functions can

propagate throughout the program causing incorrect output, security vulnerabilities, and possibly system failures.

Fix

Before continuing with the program, test the return value of *critical sensitive* functions.

For *sensitive functions*, you can explicitly ignore a return value by casting the function to `void`. Polyspace does not raise this defect for sensitive functions cast to void. This resolution is not accepted for *critical sensitive functions* because they perform more vulnerable tasks.

Examples

Sensitive Function Return Ignored

```
#include <pthread.h>

void initialize() {
    pthread_attr_t attr;

    pthread_attr_init(&attr);
}
```

This example shows a call to the sensitive function `pthread_attr_init`. The return value of `pthread_attr_init` is ignored, causing a defect.

Correction — Cast Function to `(void)`

One possible correction is to cast the function to void. This fix informs Polyspace and any reviewers that you are explicitly ignoring the return value of the sensitive function.

```
#include <pthread.h>

void initialize() {
    pthread_attr_t attr;

    (void)pthread_attr_init(&attr);
}
```

Correction — Test Return Value

One possible correction is to test the return value of `pthread_attr_init` to check for errors.

```
#include <pthread.h>
#include <stdlib.h>
#define fatal_error() abort()

void initialize() {
    pthread_attr_t attr;
    int result;

    result = pthread_attr_init(&attr);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }
}
```

Critical Function Return Ignored

```
#include <pthread.h>
extern void *start_routine(void *);

void returnnotchecked() {
    pthread_t thread_id;
    pthread_attr_t attr;
    void *res;

    (void)pthread_attr_init(&attr);
    (void)pthread_create(&thread_id, &attr, &start_routine, ((void *)0));
    pthread_join(thread_id,  &res);
}
```

In this example, two critical functions are called: `pthread_create` and `pthread_join`. The return value of the `pthread_create` is ignored by casting to void, but because `pthread_create` is a critical function (not just a sensitive function), Polyspace does not ignore this *Return value of a sensitive function not checked* defect. The other critical function, `pthread_join`, returns value that is ignored implicitly. `pthread_join` uses the return value of `pthread_create`, which was not checked.

Correction — Test the Return Value of Critical Functions

The correction for this defect is to check the return value of these critical functions to verify the function performed as expected.

```
#include <pthread.h>
#include <stdlib.h>
#define fatal_error() abort()

extern void *start_routine(void *);

void returnnotchecked() {
    pthread_t thread_id;
    pthread_attr_t attr;
    void *res;
    int result;

    (void)pthread_attr_init(&attr);
    result = pthread_create(&thread_id, &attr, &start_routine, NULL);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }

    result = pthread_join(thread_id,  &res);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `RETURN_NOT_CHECKED`
Impact: High
CWE ID: 252, 253, 690, 754

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2016b

*this not returned in copy assignment operator

`operator=` method does not return a pointer to the current object

Description

`*this` not returned from copy assignment operator occurs when assignment operators such as `operator=` and `operator+=` do not return a reference to `*this`, where `this` is a pointer to the current object. If the `operator=` method does not return `*this`, it means that `a=b` or `a.operator=(b)` is not returning the assignee `a` following the assignment.

For instance:

- The operator returns its parameter instead of a reference to the current object.

  That is, the operator has a form `MyClass & operator=(const MyClass & rhs) { ... return rhs; }` instead of `MyClass & operator=(const MyClass & rhs) { ... return *this; }`.
- The operator returns by value and not reference.

  That is, the operator has a form `MyClass operator=(const MyClass & rhs) { ... return *this; }` instead of `MyClass & operator=(const MyClass & rhs) { ... return *this; }`.

Risk

Users typically expect object assignments to behave like assignments between built-in types and expect an assignment to return the assignee. For instance, a right-associative chained assignment `a=b=c` requires that `b=c` return the assignee `b` following the assignment. If your assignment operator behaves differently, users of your class can face unexpected consequences.

The unexpected consequences occur when the assignment is part of another statement. For instance:

- If the `operator=` returns its parameter instead of a reference to the current object, the assignment `a=b` returns `b` instead of `a`. If the `operator=` performs a partial assignment of data members, following an assignment `a=b`, the data members of `a` and `b` are different. If you or another user of your class read the data members of the return value and expect the data members of `a`, you might have unexpected results. For an example, see “Return Value of operator= Same as Argument” on page 1-657.
- If the `operator=` method returns `*this` by value and not reference, a copy of `*this` is returned. If you expect to modify the result of the assignment using a statement such as `(a=b).modifyValue()`, you modify a copy of `a` instead of `a` itself.

Fix

Return `*this` from your assignment operators.

Examples

Return Value of `operator=` Same as Argument

```
class MyClass {
    public:
        MyClass(bool b, int i): m_b(b), m_i(i) {}
        const MyClass& operator=(const MyClass& obj) {
            if (&obj!=this) {
                /* Note: Only m_i is copied. m_b retains its original value. */
                m_i = obj.m_i;
            }
            return obj;
        }
        bool isOk() const { return m_b;}
        int getI() const { return m_i;}
    private:
        bool m_b;
        int m_i;
};

void main() {
        MyClass r0(true, 0), r1(false, 1);
        /* Object calling isOk is r0 and the if block executes. */
        if ( (r1 = r0).isOk()) {
            /* Do something */
```

```
        }
}
```

In this example, the operator `operator=` returns its current argument instead of a reference to `*this`.

Therefore, in `main`, the assignment `r1 = r0` returns `r0` and not `r1`. Because the `operator=` does not copy the data member `m_b`, the value of `r0.m_b` and `r1.m_b` are different. The following unexpected behavior occurs.

What You Might Expect	What Actually Happens
• The statement `(r1 = r0).isOk()` returns `r1.m_b` which has value `false` • The `if` block does not execute.	• The statement `(r1 = r0).isOk()` returns `r0.m_b` which has value `true` • The `if` block executes.

Correction — Return `*this`

One possible correction is to return `*this` from `operator=`.

```
class MyClass {
    public:
        MyClass(bool b, int i): m_b(b), m_i(i) {}
        const MyClass& operator=(const MyClass& obj) {
            if (&obj!=this) {
                /* Note: Only m_i is copied. m_b retains its original value. */
                m_i = obj.m_i;
            }
            return *this;
        }
        bool isOk() const { return m_b;}
        int getI() const { return m_i;}
    private:
        bool m_b;
        int m_i;
};

void main() {
        MyClass r0(true, 0), r1(false, 1);
        /* Object calling isOk is r0 and the if block executes. */
        if ( (r1 = r0).isOk()) {
            /* Do something */
```

```
        }
}
```

Result Information

Group: Object oriented
Language: C++
Default: Off
Command-Line Syntax: `RETURN_NOT_REF_TO_THIS`
Impact: Low

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Sensitive data printed out

Function prints sensitive data

Description

Sensitive data printed out detects print functions, such as `stdout` or `stderr`, that print sensitive information.

The checker considers the following as sensitive information:

- Return values of password manipulation functions such as `getpw`, `getpwnam` or `getpwuid`.
- Input values of functions such as the Windows-specific function `LogonUser`.

Risk

Printing sensitive information, such as passwords or user information, allows an attacker additional access to the information.

Fix

One fix for this defect is to not print out sensitive information.

If you are saving your logfile to an external file, set the file permissions so that attackers cannot access the logfile information.

Examples

Printing Passwords

```
#include <sys/types.h>
#include <pwd.h>
#include <stdio.h>
#include <string.h>
```

```
#include <unistd.h>

extern void verify_null(const char* buf);
void bug_sensitivedataprint(const char * my_user) {
    struct passwd* result, pwd;
    long bufsize = sysconf(_SC_GETPW_R_SIZE_MAX);
    char buf[1024] = "";
    getpwnam_r(my_user, &pwd, buf, bufsize, &result);
    puts("Name\n");
    puts(pwd.pw_name);
    puts("PassWord\n");
    puts(pwd.pw_passwd);
    memset(buf, 0, sizeof(buf));
    verify_null(buf);
}
```

In this example, Bug Finder flags `puts` for printing out the password `pwd.pw_passwd`.

Correction — Obfuscate the Password

One possible correction is to obfuscate the password information so that the information is not visible.

```
#include <sys/types.h>
#include <pwd.h>
#include <stdio.h>
#include <string.h>
#include <unistd.h>

extern void verify_null(const char* buf);

void sensitivedataprint(const char * my_user) {
    struct passwd* result, pwd;
    long bufsize = sysconf(_SC_GETPW_R_SIZE_MAX);
    char buf[1024] = "";
    getpwnam_r(my_user, &pwd, buf, bufsize, &result);
    puts("Name\n");
    puts(pwd.pw_name);
    puts("PassWord\n");
    puts("XXXXXXXX\n");
    memset(buf, 0, sizeof(buf));
    verify_null(buf);
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `SENSITIVE_DATA_PRINT`
Impact: Medium
CWE ID: 532, 534, 535

See Also

`Sensitive heap memory not cleared before release|Uncleared sensitive data in stack`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Sensitive heap memory not cleared before release

Sensitive data not cleared or released by memory routine

Description

Sensitive heap memory not cleared before release detects dynamically allocated memory containing sensitive data. If you do not clear the sensitive data when you free the memory, Bug Finder raises a defect on the `free` function.

Risk

If the memory zone is reallocated, an attacker can still inspect the sensitive data in the old memory zone.

Fix

Before calling `free`, clear out the sensitive data using `memset` or `SecureZeroMemory`.

Examples

Sensitive Buffer Freed, Not Cleared

```
#include <unistd.h>
#include <stdlib.h>
#include <string.h>
#include <sys/types.h>
#include <pwd.h>

void sensitiveheapnotcleared(const char * my_user) {
    struct passwd* result, pwd;
    long bufsize = sysconf(_SC_GETPW_R_SIZE_MAX);
    char* buf = (char*) malloc(1024);
    getpwnam_r(my_user, &pwd, buf, bufsize, &result);
```

```
    free(buf);
}
```

In this example, the function uses a buffer of passwords and frees the memory before the end of the function. However, the data in the memory is not cleared by using the `free` command.

Correction — Nullify Data

One possible correction is to write over the data to clear out the sensitive information. This example uses `memset` to write over the data with zeros.

```
#include <unistd.h>
#include <stdlib.h>
#include <string.h>
#include <sys/types.h>
#include <pwd.h>
#include <assert.h>

#define isNull(arr) for(int i=0;i<(sizeof(arr)/sizeof(arr[0]));i++) assert(arr[i]==0)

void sensitiveheapnotcleared(const char * my_user) {
    struct passwd* result, pwd;
    long bufsize = sysconf(_SC_GETPW_R_SIZE_MAX);
    char* buf = (char*) malloc(1024);

    if (buf) {
        getpwnam_r(my_user, &pwd, buf, bufsize, &result);
        memset(buf, 0, (size_t)1024);
        isNull(buf);
        free(buf);
    }
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `SENSITIVE_HEAP_NOT_CLEARED`
Impact: Medium
CWE ID: 244, 312, 316

See Also

`Uncleared sensitive data in stack` | `Sensitive data printed out`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Uncleared sensitive data in stack

Variable in stack is not cleared and contains sensitive data

Description

Uncleared sensitive data in stack detects static memory containing sensitive data. If you do not clear the sensitive data from your stack before exiting the function or program, Bug Finder raises a defect on the last curly brace.

Risk

Leaving sensitive information in your stack, such as passwords or user information, allows an attacker additional access to the information after your program has ended.

Fix

Before exiting a function or program, clear out the memory zones that contain sensitive data by using `memset` or `SecureZeroMemory`.

Examples

Static Buffer of Password Information

```
#include <unistd.h>
#include <sys/types.h>
#include <pwd.h>

void bug_sensitivestacknotcleared(const char * my_user) {
    struct passwd* result, pwd;
    long bufsize = sysconf(_SC_GETPW_R_SIZE_MAX);
    char buf[1024] = "";
    getpwnam_r(my_user, &pwd, buf, bufsize, &result);
}
```

In this example, a static buffer is filled with password information. The program frees the stack memory at the end of the program. However, the data is still accessible from the memory.

Correction — Clear Memory

One possible correction is to write over the memory before exiting the function. This example uses `memset` to clear the data from the buffer memory.

```
#include <unistd.h>
#include <string.h>
#include <sys/types.h>
#include <pwd.h>
#include <assert.h>

#define isNull(arr) for(int i=0;i<(sizeof(arr)/sizeof(arr[0]));i++) assert(arr[i]==0)

void corrected_sensitivestacknotcleared(const char * my_user) {
    struct passwd* result, pwd;
    long bufsize = sysconf(_SC_GETPW_R_SIZE_MAX);
    char buf[1024] = "";
    getpwnam_r(my_user, &pwd, buf, bufsize, &result);
    memset(buf, 0, (size_t)1024);
    isNull(buf);
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `SENSITIVE_STACK_NOT_CLEARED`
Impact: Medium
CWE ID: 226, 312, 316

See Also

`Sensitive heap memory not cleared before release` | `Sensitive data printed out`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Use of setjmp/longjmp

`setjmp` and `longjmp` cause deviation from normal control flow

Description

Use of setjmp/longjmp occurs when you use a combination of `setjmp` and `longjmp` or `sigsetjmp` and `siglongjmp` to deviate from normal control flow and perform non-local jumps in your code.

Risk

Using `setjmp` and `longjmp`, or `sigsetjmp` and `siglongjmp` has the following risks:

- Nonlocal jumps are vulnerable to attacks that exploit common errors such as buffer overflows. Attackers can redirect the control flow and potentially execute arbitrary code.
- Resources such as dynamically allocated memory and open files might not be closed, causing resource leaks.
- If you use `setjmp` and `longjmp` in combination with a signal handler, unexpected control flow can occur. POSIX does not specify whether `setjmp` saves the signal mask.
- Using `setjmp` and `longjmp` or `sigsetjmp` and `siglongjmp` makes your program difficult to understand and maintain.

Fix

Perform nonlocal jumps in your code using `setjmp/longjmp` or `sigsetjmp/siglongjmp` only in contexts where such jumps can be performed securely. Alternatively, use POSIX threads if possible.

In C++, to simulate throwing and catching exceptions, use standard idioms such as `throw` expressions and `catch` statements.

Examples

Use of `setjmp` and `longjmp`

```
#include <setjmp.h>
#include <signal.h>

extern int update(int);
extern void print_int(int);

static jmp_buf env;
void sighandler(int signum) {
    longjmp(env, signum);
}
void func_main(int i) {
    signal(SIGINT, sighandler);
    if (setjmp(env)==0) {
        while(1) {
            /* Main loop of program, iterates until SIGINT signal catch */
            i = update(i);
        }
    } else {
        /* Managing longjmp return */
        i = -update(i);
    }

    print_int(i);
    return;
}
```

In this example, the initial return value of `setjmp` is 0. The `update` function is called in an infinite `while` loop until the user interrupts it through a signal.

In the signal handling function, the `longjmp` statement causes a jump back to `main` and the return value of `setjmp` is now 1. Therefore, the `else` branch is executed.

Correction — Use Alternative to `setjmp` and `longjmp`

To emulate the same behavior more securely, use a `volatile` global variable instead of a combination of `setjmp` and `longjmp`.

```
#include <setjmp.h>
#include <signal.h>
```

```
extern int update(int);
extern void print_int(int);

volatile sig_atomic_t eflag = 0;

void sighandler(int signum) {
     eflag = signum;                   /* Fix: using global variable */
}

void func_main(int i) {
      /* Fix: Better design to avoid use of setjmp/longjmp */
    signal(SIGINT, sighandler);
    while(!eflag) {                   /* Fix: using global variable */
        /* Main loop of program, iterates until eflag is changed */
        i = update(i);
    }

    print_int(i);
    return;
}
```

Result Information

Group: Good practice
Language: C | C++
Default: Off
Command-Line Syntax: SETJMP_LONGJMP_USE
Impact: Low
CWE ID: 691

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

External Websites

Linux man page for setjmp

Introduced in R2015b

Shift of a negative value

Shift operator on negative value

Description

Shift of a negative value occurs when a bit-wise shift is used on a variable that can have negative values.

Risk

Shifts on negative values overwrite the sign bit that identifies a number as negative. The shift operation can result in unexpected values.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variable being shifted acquires negative values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

To fix the defect, check for negative values before the bit-wise shift operation and perform appropriate error handling.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Shifting a negative variable

```
int shifting(int val)
{
```

```
    int res = -1;
    return res << val;
}
```

In the return statement, the variable `res` is shifted a certain number of bits to the left. However, because `res` is negative, the shift might overwrite the sign bit.

Correction — Change the Data Type

One possible correction is to change the data type of the shifted variable to unsigned. This correction eliminates the sign bit, so left shifting does not change the sign of the variable.

```
int shifting(int val)
{
    unsigned int res = -1;
    return res << val;
}
```

Check Information

Group: Numerical
Language: C | C++
Default: Off
Command-Line Syntax: `SHIFT_NEG`
Impact: Low
CWE ID: 189

See Also

`Shift operation overflow`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Shift operation overflow

Overflow from shifting operation

Description

Shift operation overflow occurs when a shift operation can result in values that cannot be represented by the result data type. The data type of a variable determines the number of bytes allocated for the variable storage and constrains the range of allowed values.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Shift operation overflows can result in undefined behavior.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variables in the shift operation acquire their current values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

You can fix the defect by:

- Using a bigger data type for the result of the shift operation so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Left Shift of Integer

```
int left_shift(void) {

    int foo = 33;
    return 1 << foo;
}
```

In the return statement of this function, bit-wise shift operation is performed shifting 1 `foo` bits to the left. However, an `int` has only 32 bits, so the range of the shift must be between 0 and 31. Therefore, this shift operation causes an overflow.

Correction — Different storage type

One possible correction is to store the shift operation result in a larger data type. In this example, by returning a `long long` instead of an `int`, the overflow defect is fixed.

```
long long left_shift(void) {

    int foo = 33;
    return 1LL << foo;
}
```

Check Information

Group: Numerical
Language: C | C++
Default: Off
Command-Line Syntax: `SHIFT_OVFL`
Impact: Low
CWE ID: 189, 190

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Side effect of expression ignored

`sizeof`, `_Alignof`, or `_Generic` operates on expression with side effect

Description

Side effect of expression ignored occurs when the `sizeof`, `_Alignof`, or `_Generic` operator operates on an expression with a side effect. When evaluated, an expression with side effect modifies at least one of the variables in the expression.

For instance, the defect checker does not flag `sizeof(n+1)` because `n+1` does not modify `n`. The checker flags `sizeof(n++)` because `n++` is intended to modify `n`.

The check also applies to the C++ operator `alignof` and its C extensions, `__alignof__` and `__typeof__`.

Risk

The expression in a `_Alignof` or `_Generic` operator is not evaluated. The expression in a `sizeof` operator is evaluated only if it is required for calculating the size of a variable-length array, for instance, `sizeof(a[n++])`.

When an expression with a side effect is not evaluated, the variable modification from the side effect does not happen. If you rely on the modification, you can see unexpected results.

Fix

Evaluate the expression with a side effect in a separate statement, and then use the result in a `sizeof`, `_Alignof`, or `_Generic` operator.

For instance, instead of:

```
a = sizeof(n++);
```

perform the operation in two steps:

```
n++;
a = sizeof(n);
```

The checker considers a function call as an expression with a side effect. Even if the function does not have side effects now, it might have side effects on later additions. The code is more maintainable if you call the function outside the `sizeof` operator.

Examples

Increment Operator in `sizeof`

```
#include <stdio.h>

void func(void) {
    unsigned int a = 1U;
    unsigned int b = (unsigned int)sizeof(++a);
    printf ("%u, %u\n", a, b);
}
```

In this example, `sizeof` operates on `++a`, which is intended to modify `a`. Because the expression is not evaluated, the modification does not happen. The `printf` statement shows that `a` still has the value `1`.

Correction — Perform Increment Outside `sizeof`

One possible correction is to perform the increment first, and then provide the result to the `sizeof` operator.

```
#include <stdio.h>

void func(void) {
    unsigned int a = 1U;
    ++a;
    unsigned int b = (unsigned int)sizeof (a);
    printf ("%u, %u\n", a, b);
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `SIDE_EFFECT_IGNORED`

Impact: Low

See Also

`MISRA C:2012 Rule 13.6`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Side effect in arguments to unsafe macro

Macro contains arguments that can be evaluated multiple times or not evaluated

Description

Side effect in arguments to unsafe macro occurs when you call an unsafe macro with an expression that has a side effect.

- *Unsafe macro*: When expanded, an unsafe macro evaluates its arguments multiple times or does not evaluate its argument at all.

  For instance, the `ABS` macro evaluates its argument `x` twice.

  ```
  #define ABS(x) (((x) < 0) ? -(x) : (x))
  ```

- *Side effect*: When evaluated, an expression with a side effect modifies at least one of the variables in the expression.

  For instance, `++n` modifies `n`, but `n+1` does not modify `n`.

  The checker does not consider side effects in nested macros. The checker also does not consider function calls or volatile variable access as side effects.

Risk

If you call an unsafe macro with an expression that has a side effect, the expression is evaluated multiple times or not evaluated at all. The side effect can occur multiple times or not occur at all, causing unexpected behavior.

For instance, in the call `MACRO(++n)`, you expect only one increment of the variable `n`. If `MACRO` is an unsafe macro, the increment happens more than once or does not happen at all.

The checker flags expressions with side effects in the `assert` macro because the `assert` macro is disabled in non-debug mode. To compile in non-debug mode, you define the `NDEBUG` macro during compilation. For instance, in GCC, you use the flag `-DNDEBUG`.

Fix

Evaluate the expression with a side effect in a separate statement, and then use the result as a macro argument.

For instance, instead of:

```
MACRO(++n);
```

perform the operation in two steps:

```
++n;
MACRO(n);
```

Alternatively, use an inline function instead of a macro. Pass the expression with side effect as argument to the inline function.

The checker considers modifications of a local variable defined only in the block scope of a macro body as a side effect. This defect cannot happen since the variable is visible only in the macro body. If you see a defect of this kind, ignore the defect.

Examples

Macro Argument with Side Effects

```
#define ABS(x) (((x) < 0) ? -(x) : (x))

void func(int n) {
  /* Validate that n is within the desired range */
  int m = ABS(++n);

  /* ... */
}
```

In this example, the ABS macro evaluates its argument twice. The second evaluation can result in an unintended increment.

Correction — Separate Evaluation of Expression from Macro Usage

One possible correction is to first perform the increment, and then pass the result to the macro.

```
#define ABS(x) (((x) < 0) ? -(x) : (x))

void func(int n) {
  /* Validate that n is within the desired range */
  ++n;
  int m = ABS(n);

  /* ... */
}
```

Correction — Evaluate Expression in Inline Function

Another possible correction is to evaluate the expression in an inline function.

```
static inline int iabs(int x) {
  return (((x) < 0) ? -(x) : (x));
}

void func(int n) {
  /* Validate that n is within the desired range */

int m = iabs(++n);

  /* ... */
}
```

Result Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: `SIDE_EFFECT_IN_UNSAFE_MACRO_ARG`
Impact: Medium

See Also

`MISRA C:2012 Rule 13.2` | `MISRA C:2012 Rule 13.3` | `MISRA C:2012 Rule 13.4` | `Side effect of expression ignored` | `Stream argument with possibly unintended side effects`

Topics

“Interpret Polyspace Bug Finder Access Results”

“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

Function called from signal handler not asynchronous-safe

Call to interrupted function causes undefined program behavior

Description

Function called from signal handler not asynchronous-safe occurs when a signal handler calls a function that is not asynchronous-safe according to the POSIX standard. An asynchronous-safe function can be interrupted at any point in its execution, then called again without causing an inconsistent state. It can also correctly handle global data that might be in an inconsistent state.

If a signal handler calls another function that calls an asynchronous-unsafe function, the defect appears on the function call in the signal handler. The defect traceback shows the full path from the signal handler to the asynchronous-unsafe function.

Risk

When a signal handler is invoked, the execution of the program is interrupted. After the handler is finished, program execution resumes at the point of interruption. If a function is executing at the time of the interruption, calling it from within the signal handler is undefined behavior, unless it is asynchronous-safe.

Fix

The POSIX standard defines these functions as asynchronous-safe. You can call these functions from a signal handler.

`_exit()`	`getpgrp()`	`setsockopt()`
`_Exit()`	`getpid()`	`setuid()`
`abort()`	`getppid()`	`shutdown()`
`accept()`	`getsockname()`	`sigaction()`
`access()`	`getsockopt()`	`sigaddset()`

aio_error()	getuid()	sigdelset()
aio_return()	kill()	sigemptyset()
aio_suspend()	link()	sigfillset()
alarm()	linkat()	sigismember()
bind()	listen()	signal()
cfgetispeed()	lseek()	sigpause()
cfgetospeed()	lstat()	sigpending()
cfsetispeed()	mkdir()	sigprocmask()
cfsetospeed()	mkdirat()	sigqueue()
chdir()	mkfifo()	sigset()
chmod()	mkfifoat()	sigsuspend()
chown()	mknod()	sleep()
clock_gettime()	mknodat()	sockatmark()
close()	open()	socket()
connect()	openat()	socketpair()
creat()	pathconf()	stat()
dup()	pause()	symlink()
dup2()	pipe()	symlinkat()
execl()	poll()	sysconf()
execle()	posix_trace_event()	tcdrain()
execv()	pselect()	tcflow()
execve()	pthread_kill()	tcflush()
faccessat()	pthread_self()	tcgetattr()
fchdir()	pthread_sigmask()	tcgetpgrp()
fchmod()	quick_exit()	tcsendbreak()
fchmodat()	raise()	tcsetattr()
fchown()	read()	tcsetpgrp()
fchownat()	readlink()	time()
fcntl()	readlinkat()	timer_getoverrun()

fdatasync()	recv()	timer_gettime()
fexecve()	recvfrom()	timer_settime()
fork()	recvmsg()	times()
fpathconf()	rename()	umask()
fstat()	renameat()	uname()
fstatat()	rmdir()	unlink()
fsync()	select()	unlinkat()
ftruncate()	sem_post()	utime()
futimens()	send()	utimensat()
getegid()	sendmsg()	utimes()
geteuid()	sendto()	wait()
getgid()	setgid()	waitpid()
getgroups()	setpgid()	write()
getpeername()	setsid()	

Functions not in the previous table are not asynchronous-safe, and should not be called from a signal hander.

Examples

Call to `printf()` Inside Signal Handler

```
#include <signal.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <setjmp.h>
#include <syslog.h>
#include <unistd.h>

#define SIZE20 20

extern volatile sig_atomic_t e_flag;

void display_info(const char *info)
```

```
{
    if (info)
    {
        (void)fputs(info, stderr);
    }
}

void sig_handler(int signum)
{
    /* Call function printf() that is not
    asynchronous-safe */
    printf("signal %d received.", signum);
    e_flag = 1;
}

int main(void)
{
    e_flag = 0;
    if (signal(SIGINT, sig_handler) == SIG_ERR)
    {
        /* Handle error */
    }
    char *info = (char *)calloc(SIZE20, sizeof(char));
    if (info == NULL)
    {
        /* Handle Error */
    }
    while (!e_flag)
    {
        /* Main loop program code */
        display_info(info);
        /* More program code */
    }
    free(info);
    info = NULL;
    return 0;
}
```

In this example, `sig_handler` calls `printf()` when catching a signal. If the handler catches another signal while `printf()` is executing, the behavior of the program is undefined.

Correction — Set Flag Only in Signal Handler

Use your signal handler to set only the value of a flag. `e_flag` is of type volatile `sig_atomic_t`. `sig_handler` can safely access it asynchronously.

```
#include <signal.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <setjmp.h>
#include <syslog.h>
#include <unistd.h>

#define SIZE20 20

extern volatile sig_atomic_t e_flag;

void display_info(const char *info)
{
    if (info)
    {
        (void)fputs(info, stderr);
    }
}

void sig_handler1(int signum)
{
    int s0 = signum;
    e_flag = 1;
}

int func(void)
{
    e_flag = 0;
    if (signal(SIGINT, sig_handler1) == SIG_ERR)
    {
        /* Handle error */
    }
    char *info = (char *)calloc(SIZE20, 1);
    if (info == NULL)
    {
        /* Handle error */
    }
    while (!e_flag)
```

```
    {
        /* Main loop program code */
        display_info(info);
        /* More program code */
    }
    free(info);
    info = NULL;
    return 0;
}
```

Result Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: SIG_HANDLER_ASYNC_UNSAFE
Impact: Medium
CWE ID: 364, 387, 413, 479, 663, 828

See Also

`Function called from signal handler not asynchronous-safe (strict)` | `Return from computational exception signal handler` | `Shared data access within signal handler` | `Signal call from within signal handler`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Function called from signal handler not asynchronous-safe (strict)

Call to interrupted function causes undefined program behavior

Description

Function called from signal handler not asynchronous-safe (strict) occurs when a signal handler calls a function that is not asynchronous-safe according to the C standard. An asynchronous-safe function can be interrupted at any point in its execution, then called again without causing an inconsistent state. It can also correctly handle global data that might be in an inconsistent state.

When you select the checker **Function called from signal handler not asynchronous-safe**, the checker detects calls to functions that are not asynchronous-safe according to the POSIX standard. **Function called from signal handler not asynchronous-safe (strict)** does not raise a defect for these cases. **Function called from signal handler not asynchronous-safe (strict)** raises a defect for functions that are asynchronous-safe according to the POSIX standard but not according to the C standard.

If a signal handler calls another function that calls an asynchronous-unsafe function, the defect appears on the function call in the signal handler. The defect traceback shows the full path from the signal handler to the asynchronous-unsafe function.

Risk

When a signal handler is invoked, the execution of the program is interrupted. After the handler is finished, program execution resumes at the point of interruption. If a function is executing at the time of the interruption, calling it from within the signal handler is undefined behavior, unless it is asynchronous-safe.

Fix

The C standard defines the following functions as asynchronous-safe. You can call these functions from a signal handler:

- abort()
- _Exit()
- quick_exit()
- signal()

Examples

Call to raise() Inside Signal Handler

```
#include <signal.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <setjmp.h>
#include <syslog.h>
#include <unistd.h>

void SIG_ERR_handler(int signum)
{
    int s0 = signum;
    /* SIGTERM specific handling */
}

void sig_handler(int signum)
{
    int s0 = signum;
    /* Call raise() */
    if (raise(SIGTERM) != 0) {
        /* Handle error */
    }
}

int finc(void)
{
    if (signal(SIGTERM, SIG_ERR_handler) == SIG_ERR)
    {
        /* Handle error */
    }
    if (signal(SIGINT, sig_handler) == SIG_ERR)
    {
        /* Handle error */
```

```
    }
    /* Program code */
    if (raise(SIGINT) != 0)
    {
        /* Handle error */
    }
    /* More code */
    return 0;
}
```

In this example, `sig_handler` calls `raise()` when catching a signal. If the handler catches another signal while `raise()` is executing, the behavior of the program is undefined.

Correction — Remove Call to `raise()` in Signal Handler

According to the C standard, the only functions that you can safely call from a signal handler are `abort()`, `_Exit()`, `quick_exit()`, and `signal()`.

```
#include <signal.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <setjmp.h>
#include <syslog.h>
#include <unistd.h>

void SIG_ERR_handler(int signum)
{
    int s0 = signum;
    /* SIGTERM specific handling */
}
void sig_handler(int signum)
{
    int s0 = signum;


}

int func(void)
{
    if (signal(SIGTERM, SIG_ERR_handler) == SIG_ERR)
```

```
    {
        /* Handle error */
    }
    if (signal(SIGINT, sig_handler) == SIG_ERR)
    {
        /* Handle error */
    }
    /* Program code */
    if (raise(SIGINT) != 0)
    {
        /* Handle error */
    }
    /* More code */
    return 0;
}
```

Result Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: `SIG_HANDLER_ASYNC_UNSAFE_STRICT`
Impact: Medium
CWE ID: 364, 387, 413, 479, 663, 828

See Also

`Function called from signal handler not asynchronous-safe` | `Shared data access within signal handler` | `Signal call from within signal handler`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Signal call from within signal handler

Nonpersistent signal handler calling `signal()` in Windows system causes race condition

Description

Signal call from within signal handler occurs when you call `signal()` from a nonpersistent signal handler on a Windows platform.

Risk

A nonpersistent signal handler is reset after catching a signal. The handler does not catch subsequent signals unless the handler is reestablished by calling `signal()`. A nonpersistent signal handler on a Windows platform is reset to `SIG_DFL`. If another signal interrupts the execution of the handler, that signal can cause a race condition between `SIG_DFL` and the existing signal handler. A call to `signal()` can also result in an infinite loop inside the handler.

Fix

Do not call `signal()` from a signal handler on Windows platforms.

Examples

`signal()` Called from Signal Handler

```
#include <stdio.h>
#include <stdlib.h>
#include <signal.h>
#include <unistd.h>



volatile sig_atomic_t e_flag = 0;

void sig_handler(int signum)
```

```
{
    int s0 = signum;
    e_flag = 1;

    /* Call signal() to reestablish sig_handler
    upon receiving SIG_ERR. */

    if (signal(s0, sig_handler) == SIG_ERR)
    {
        /* Handle error */
    }
}

void func(void)
{
        if (signal(SIGINT, sig_handler) == SIG_ERR)
        {
            /* Handle error */

        }
  /* more code */
}
```

In this example, the definition of `sig_handler()` includes a call to `signal()` when the handler catches `SIG_ERR`. On Windows platforms, signal handlers are nonpersistent. This code can result in a race condition.

Correction — Do Not Call `signal()` from Signal Handler

If your code requires the use of a persistent signal handler on a Windows platform, use a persistent signal handler after performing a thorough risk analysis.

```
#include <stdio.h>
#include <stdlib.h>
#include <signal.h>
#include <unistd.h>



volatile sig_atomic_t e_flag = 0;


void sig_handler(int signum)
```

```
{
    int s0 = signum;
    e_flag = 1;
    /* No call to signal() */
}

int main(void)
{

        if (signal(SIGINT, sig_handler) == SIG_ERR)
        {
            /* Handle error */

        }
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: SIG_HANDLER_CALLING_SIGNAL
Impact: Medium
CWE ID: 387, 474

See Also

Function called from signal handler not asynchronous-safe | Return from computational exception signal handler | Shared data access within signal handler

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Return from computational exception signal handler

Undefined behavior when signal handler returns normally from program error

Description

Return from computational exception signal handler occurs when a signal handler returns after catching a computational exception signal `SIGFPE`, `SIGILL`, or `SIGSEGV`.

Risk

A signal handler that returns normally from a computational exception is undefined behavior. Even if the handler attempts to fix the error that triggered the signal, the program can behave unexpectedly.

Fix

Check the validity of the values of your variables before the computation to avoid using a signal handler to catch exceptions. If you cannot avoid a handler to catch computation exception signals, call `abort()`, `quick_exit()`, or `_Exit()` in the handler to stop the program.

Examples

Signal Handler Return from Division by Zero

```
#include <errno.h>
#include <limits.h>
#include <signal.h>
#include <stdlib.h>

static volatile sig_atomic_t denom;
/* Declare signal handler to catch division by zero
computation error. */
```

```
void sig_handler(int s)
{
    int s0 = s;
    if (denom == 0)
    {
        denom = 1;
    }
    /* Normal return from computation exception
    signal */
    return;
}


long func(int v)
{
    denom = (sig_atomic_t)v;

        if (signal(SIGFPE, sig_handler) == SIG_ERR)
        {
            /* Handle error */
        }

    long result = 100 / (long)denom;
    return result;
}
```

In this example, `sig_handler` is declared to handle a division by zero computation error. The handler changes the value of `denom` if it is zero and returns, which is undefined behavior.

Correction — Call `abort()` to Terminate Program

After catching a computational exception, call `abort()` from `sig_handler` to exit the program without further error.

```
#include <errno.h>
#include <limits.h>
#include <signal.h>
#include <stdlib.h>

static volatile sig_atomic_t denom;
/* Declare signal handler to catch division by zero
```

```
computation error. */

void sig_handler(int s)
{
    int s0 = s;
    /* call to abort() to exit the program */
    abort();
}

long func(int v)
{
    denom = (sig_atomic_t)v;

        if (signal(SIGFPE, sig_handler) == SIG_ERR)
        {
            /* Handle error */
        }

    long result = 100 / (long)denom;
    return result;
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `SIG_HANDLER_COMP_EXCP_RETURN`
Impact: Low
CWE ID: 387

See Also

`Function called from signal handler not asynchronous-safe` | `Function called from signal handler not asynchronous-safe (strict)` | `Signal call from within signal handler`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Misuse of errno in a signal handler

You read `errno` after calling an `errno`-setting function in a signal handler

Description

Misuse of errno in a signal handler occurs when you call one of these functions in a signal handler:

- `signal`: You call the `signal` function in a signal handler and then read the value of `errno`.

  For instance, the signal handler function `handler` calls `signal` and then calls `perror`, which reads `errno`.

  ```
  void handler(int signum) {
    pfv old_handler = signal(signum, SIG_DFL);
    if (old_handler == SIG_ERR) {
      perror("SIGINT handler");
    }
  }
  ```

- `errno`-setting POSIX function: You call an `errno`-setting POSIX function in a signal handler but do not restore `errno` when returning from the signal handler.

  For instance, the signal handler function `handler` calls `waitpid`, which changes `errno`, but does not restore `errno` before returning.

  ```
  void handler(int signum) {
    int rc = waitpid(-1, NULL, WNOHANG);
    if (ECHILD != errno) {
    }
  }
  ```

Risk

In each case that the checker flags, you risk relying on an indeterminate value of `errno`.

- `signal`: If the call to `signal` in a signal handler fails, the value of `errno` is indeterminate (see C11 Standard, Sec. 7.14.1.1). If you rely on a specific value of `errno`, you can see unexpected results.
- `errno`-setting POSIX function: An `errno`-setting function sets `errno` on failure. If you read `errno` after a signal handler is called and the signal handler itself calls an `errno`-setting function, you can see unexpected results.

Fix

Avoid situations where you risk relying on an indeterminate value of `errno`.

- `signal`: After calling the `signal` function in a signal handler, do not read `errno` or use a function that reads `errno`.
- `errno`-setting POSIX function: Before calling an `errno`-setting function in a signal handler, save `errno` to a temporary variable. Restore `errno` from this variable before returning from the signal handler.

Examples

Reading `errno` After `signal` Call in Signal Handler

```
#include <signal.h>
#include <stdlib.h>
#include <stdio.h>

#define fatal_error() abort()

void handler(int signum) {
    if (signal(signum, SIG_DFL) == SIG_ERR) {
        perror("SIGINT handler");
    }
}

int func(void) {
    if (signal(SIGINT, handler) == SIG_ERR) {
        /* Handle error */
        fatal_error();
    }
    /* Program code */
```

```
    if (raise(SIGINT) != 0) {
        /* Handle error */
        fatal_error();
    }
    return 0;
}
```

In this example, the function `handler` is called to handle the `SIGINT` signal. In the body of `handler`, the `signal` function is called. Following this call, the value of `errno` is indeterminate. The checker raises a defect when the `perror` function is called because `perror` relies on the value of `errno`.

Correction — Avoid Reading `errno` After `signal` Call

One possible correction is to not read `errno` after calling the `signal` function in a signal handler. The corrected code here calls the `abort` function via the `fatal_error` macro instead of the `perror` function.

```
#include <signal.h>
#include <stdlib.h>
#include <stdio.h>

#define fatal_error() abort()

void handler(int signum) {
    if (signal(signum, SIG_DFL) == SIG_ERR) {
        fatal_error();
    }
}

int func(void) {
    if (signal(SIGINT, handler) == SIG_ERR) {
        /* Handle error */
        fatal_error();
    }
    /* Program code */
    if (raise(SIGINT) != 0) {
        /* Handle error */
        fatal_error();
    }
    return 0;
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `SIG_HANDLER_ERRNO_MISUSE`
Impact: Medium

See Also

`Errno not checked` | `Errno not reset` | `Function called from signal handler not asynchronous-safe`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Shared data access within signal handler

Access or modification of shared data causes inconsistent state

Description

Shared data access within signal handler occurs when you access or modify a shared object inside a signal handler.

Risk

When you define a signal handler function to access or modify a shared object, the handler accesses or modifies the shared object when it receives a signal. If another function is already accessing the shared object, that function causes a race condition and can leave the data in an inconsistent state.

Fix

To access or modify shared objects inside a signal handler, check that the objects are lock-free atomic, or, if they are integers, declare them as `volatile sig_atomic_t`.

Examples

`int` Variable Access in Signal Handler

```
#include <signal.h>
#include <stdlib.h>
#include <string.h>

/* declare global variable. */
int e_flag;

void sig_handler(int signum)
{
    /* Signal handler accesses variable that is not
    of type volatile sig_atomic_t. */
```

```
    e_flag = signum;
}

int func(void)
{
    if (signal(SIGINT, sig_handler) == SIG_ERR)
    {
        /* Handle error */
        abort();
    }
    /* Program code */
    if (raise(SIGINT) != 0)
    {
        /* Handle error */
        abort();
    }
    /* More code */
    return 0;
}
```

In this example, `sig_handler` accesses `e_flag`, a variable of type `int`. A concurrent access by another function can leave `e_flag` in an inconsistent state.

Correction — Declare Variable of Type `volatile sig_atomic_t`

Before you access a shared variable from a signal handler, declare the variable with type `volatile sig_atomic_t` instead of `int`. You can safely access variables of this type asynchronously.

```
#include <signal.h>
#include <stdlib.h>
#include <string.h>

/* Declare variable of type volatile sig_atomic_t. */
volatile sig_atomic_t e_flag;
void sig_handler(int signum)
{
    /* Use variable of proper type inside signal handler. */
    e_flag = signum;

}
```

```
int func(void)
{
    if (signal(SIGINT, sig_handler) == SIG_ERR)
    {
        /* Handle error */
        abort();
    }
    /* Program code */
    if (raise(SIGINT) != 0)
    {
        /* Handle error */
        abort();
    }
    /* More code */
    return 0;
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `SIG_HANDLER_SHARED_OBJECT`
Impact: Medium
CWE ID: 364, 413

See Also

`Function called from signal handler not asynchronous-safe` | `Signal call from within signal handler`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Sign change integer conversion overflow

Overflow when converting between signed and unsigned integers

Description

Sign change integer conversion overflow occurs when converting an unsigned integer to a signed integer. If the variable does not have enough bytes to represent both the original constant and the sign bit, the conversion overflows.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Convert from `unsigned char` to `char`

```
char sign_change(void) {
    unsigned char count = 255;

    return (char)count;
}
```

In the return statement, the unsigned character variable `count` is converted to a signed character. However, `char` has 8 bits, 1 for the sign of the constant and 7 to represent the number. The conversion operation overflows because 255 uses 8 bits.

Correction — Change conversion types

One possible correction is using a larger integer type. By using an `int`, there are enough bits to represent the sign and the number value.

```
int sign_change(void) {
    unsigned char count = 255;

    return (int)count;
}
```

Check Information

Group: Numerical
Language: C | C++
Default: On
Command-Line Syntax: `SIGN_CHANGE`
Impact: Medium
CWE ID: 192, 194, 195, 196

See Also

`Float conversion overflow` | `Integer conversion overflow` | `Unsigned integer conversion overflow`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Signal call in multithreaded program

Program with multiple threads uses `signal` function

Description

Signal call in multithreaded program occurs when you use the `signal()` function in a program with multiple threads.

Risk

According to the C11 standard (Section 7.14.1.1), use of the `signal()` function in a multithreaded program is undefined behavior.

Fix

Depending on your intent, use other ways to perform an asynchronous action on a specific thread.

Examples

Use of `signal()` Function to Terminate Loop in Thread

```
#include <signal.h>
#include <stddef.h>
#include <threads.h>

volatile sig_atomic_t flag = 0;

void handler(int signum) {
  flag = 1;
}

/* Runs until user sends SIGUSR1 */
int func(void *data) {
  while (!flag) {
```

```
    /* ... */
  }
  return 0;
}

int main(void) {
  signal(SIGINT, handler); /* Undefined behavior */
  thrd_t tid;

  if (thrd_success != thrd_create(&tid, func, NULL)) {
    /* Handle error */
  }
  /* ... */
  return 0;
}
```

In this example, the `signal` function is used to terminate a `while` loop in the thread created with `thrd_create`.

Correction — Use `atomic_bool` Variable to Terminate Loop

One possible correction is to use an `atomic_bool` variable that multiple threads can access. In the corrected example, the child thread evaluates this variable before every loop iteration. After completing the program, you can modify this variable so that the child thread exits the loop.

```
#include <stdatomic.h>
#include <stdbool.h>
#include <stddef.h>
#include <threads.h>

atomic_bool flag = ATOMIC_VAR_INIT(false);

int func(void *data) {
  while (!flag) {
    /* ... */
  }
  return 0;
}

int main(void) {
  thrd_t tid;
```

```
  if (thrd_success != thrd_create(&tid, func, NULL)) {
    /* Handle error */
  }
  /* ... */
  /* Set flag when done */
  flag = true;

  return 0;
}
```

Result Information

Group: Concurrency
Language: C | C++
Default: Off
Command-Line Syntax: SIGNAL_USE_IN_MULTITHREADED_PROGRAM
Impact: Low

See Also

`Function called from signal handler not asynchronous-safe` | `MISRA C:2012 Rule 21.5` | `Signal call from within signal handler`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

Possible misuse of sizeof

Use of `sizeof` operator can cause unintended results

Description

Possible misuse of sizeof occurs when Polyspace Bug Finder detects possibly unintended results from the use of `sizeof` operator. For instance:

- You use the `sizeof` operator on an array parameter name, expecting the array size. However, the array parameter name by itself is a pointer. The `sizeof` operator returns the size of that pointer.
- You use the `sizeof` operator on an array element, expecting the array size. However, the operator returns the size of the array element.
- The size argument of certain functions such as `strncmp` or `wcsncpy` is incorrect because you used the `sizeof` operator earlier with possibly incorrect expectations. For instance:
  - In a function call `strncmp(string1, string2, num)`, `num` is obtained from an incorrect use of the `sizeof` operator on a pointer.
  - In a function call `wcsncpy(destination, source, num)`, `num` is the not the number of wide characters but a size in bytes obtained by using the `sizeof` operator. For instance, you use `wcsncpy(destination, source, sizeof(destination) - 1)` instead of `wcsncpy(destination, source, (sizeof(desintation)/sizeof(wchar_t)) - 1)`.

Risk

Incorrect use of the `sizeof` operator can cause the following issues:

- If you expect the `sizeof` operator to return array size and use the return value to constrain a loop, the number of loop runs are smaller than what you expect.
- If you use the return value of `sizeof` operator to allocate a buffer, the buffer size is smaller than what you require. Insufficient buffer can lead to resultant weaknesses such as buffer overflows.

- If you use the return value of `sizeof` operator incorrectly in a function call, the function does not behave as you expect.

Fix

Possible fixes are:

- Do not use the `sizeof` operator on an array parameter name or array element to determine array size.

  The best practice is to pass the array size as a separate function parameter and use that parameter in the function body.
- Use the `sizeof` operator carefully to determine the number argument of functions such as `strncmp` or `wcsncpy`. For instance, for wide string functions such as `wcsncpy`, use the number of wide characters as argument instead of the number of bytes.

Examples

`sizeof` Used Incorrectly to Determine Array Size

```
#define MAX_SIZE 1024

void func(int a[MAX_SIZE]) {
    int i;

    for (i = 0; i < sizeof(a)/sizeof(int); i++)    {
        a[i] = i + 1;
    }
}
```

In this example, `sizeof(a)` returns the size of the pointer `a` and not the array size.

Correction — Determine Array Size in Another Way

One possible correction is to use another means to determine the array size.

```
#define MAX_SIZE 1024

void func(int a[MAX_SIZE]) {
```

```
    int i;

    for (i = 0; i < MAX_SIZE; i++)    {
        a[i] = i + 1;
    }
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: SIZEOF_MISUSE
Impact: High
CWE ID: 467

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

External Websites

Linux man page for strncmp
Linux man page for wcsncpy

Introduced in R2015b

Function that can spuriously fail not wrapped in loop

Loop checks failure condition after possible spurious failure

Description

Function that can spuriously fail not wrapped in loop occurs when the following atomic compare and exchange functions that can fail spuriously are called from outside a loop.

- C atomic functions:
  - `atomic_compare_exchange_weak()`
  - `atomic_compare_exchange_weak_explicit()`
- C++ atomic functions:
  - `std::atomic<T>::compare_exchange_weak(T* expected, T desired)`
  - `std::atomic<T>::compare_exchange_weak_explicit(T* expected, T desired, std::memory_order succ, std::memory_order fail)`
  - `std::atomic_compare_exchange_weak(std::atomic<T>* obj, T* expected, T desired)`
  - `std::atomic_compare_exchange_weak_explicit(volatile std::atomic<T>* obj, T* expected, T desired, std::memory_order succ, std::memory_order fail)`

The functions compare the memory contents of the object representations pointed to by `obj` and `expected`. The comparison can spuriously return false even if the memory contents are equal. This spurious failure makes the functions faster on some platforms.

Risk

An atomic compare and exchange function that spuriously fails can cause unexpected results and unexpected control flow.

Fix

Wrap atomic compare and exchange functions that can spuriously fail in a loop. The loop checks the failure condition after a possible spurious failure.

Examples

`atomic_compare_exchange_weak()` Not Wrapped in Loop

```
#include <stdatomic.h>

extern void reset_count(void);
atomic_int count = ATOMIC_VAR_INIT(0);

void increment_count(void)
{
    int old_count = atomic_load(&count);
    int new_count;
    new_count = old_count + 1;
    if (!atomic_compare_exchange_weak(&count, &old_count, new_count))
        reset_count();

}
```

In this example, `increment_count()` uses `atomic_compare_exchange_weak()` to compare `count` and `old_count`. If the counts are equal, `count` is incremented to `new_count`. If they are not equal, the count is reset. When `atomic_compare_exchange_weak()` fails spuriously, the count is reset unnecessarily.

Correction — Wrap `atomic_compare_exchange_weak()` in a `while` Loop

One possible correction is to wrap the call to `atomic_compare_exchange_weak()` in a `while` loop. The loop checks the failure condition after a possible spurious failure.

```
#include <stdatomic.h>

extern void reset_count(void);
atomic_int count = ATOMIC_VAR_INIT(0);

void increment_count(void)
{
```

```
    int old_count = atomic_load(&count);
    int new_count;
    new_count = old_count + 1;

    do {
        reset_count();

    } while (!atomic_compare_exchange_weak(&count, &old_count, new_count));

}
```

Result Information

Group: Concurrency
Language: C | C++
Default: Off
Command-Line Syntax: SPURIOUS_FAILURE_NOT_WRAPPED_IN_LOOP
Impact: Low

See Also

`Function that can spuriously wake up not wrapped in loop` | `Returned value of a sensitive function not checked`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

Function that can spuriously wake up not wrapped in loop

Loop checks wake-up condition after possible spurious wake-up

Description

Function that can spuriously wake up not wrapped in loop occurs when the following wait-on-condition functions are called from outside a loop:

- C functions:
  - `cnd_wait()`
  - `cnd_timedwait()`
- POSIX functions:
  - `pthread_cond_wait()`
  - `pthread_cond_timedwait()`
- C++ `std::condition_variable` and `std::condition_variable_any` class member functions:
  - `wait()`
  - `wait_until()`
  - `wait_for()`

Wait-on-condition functions pause the execution of the calling thread when a specified condition is met. The thread wakes up and resumes once another thread notifies it with `cnd_broadcast()` or an equivalent function. The wake-up notification can be spurious or malicious.

Risk

If a thread receives a spurious wake-up notification and the condition of the wait-on-condition function is not checked, the thread can wake up prematurely. The wake-up can cause unexpected control flow, indefinite blocking of other threads, or denial of service.

Fix

Wrap wait-on-condition functions that can wake up spuriously in a loop. The loop checks the wake-up condition after a possible spurious wake-up notification.

Examples

`cnd_wait()` Not Wrapped in Loop

```
#include <stdio.h>
#include <stddef.h>
#include <threads.h>

#define THRESHOLD 100

static mtx_t lock;
static cnd_t cond;

void func(int input)
{
    if (thrd_success != mtx_lock(&lock)) {
        /* Handle error */
    }
    /* test condition to pause thread */
    if (input > THRESHOLD) {
        if (thrd_success != cnd_wait(&cond, &lock)) {
            /* Handle error */
        }
    }
    /* Proceed if condition to pause does not hold */


    if (thrd_success != mtx_unlock(&lock)) {
        /* Handle error */
    }
}
```

In this example, the thread uses `cnd_wait()` to pause execution when `input` is greater than `THRESHOLD`. The paused thread can resume if another thread uses `cnd_broadcast()`, which notifies all the threads. This notification causes the thread to wake up even if the pause condition is still true.

Correction — Wrap `cnd_wait()` in a `while` Loop

One possible correction is to wrap `cnd_wait()` in a `while` loop. The loop checks the pause condition after the thread receives a possible spurious wake-up notification.

```
#include <stdio.h>
#include <stddef.h>
#include <threads.h>

#define THRESHOLD 100

static mtx_t lock;
static cnd_t cond;

void func(int input)
{
    if (thrd_success != mtx_lock(&lock)) {
        /* Handle error */
    }
    /* test condition to pause thread */
    while (input > THRESHOLD) {
        if (thrd_success != cnd_wait(&cond, &lock)) {
            /* Handle error */
        }
    }
    /* Proceed if condition to pause does not hold */


    if (thrd_success != mtx_unlock(&lock)) {
        /* Handle error */
    }
}
```

Result Information

Group: Concurrency
Language: C | C++
Default: Off
Command-Line Syntax: SPURIOUS_WAKEUP_NOT_WRAPPED_IN_LOOP
Impact: Low

See Also

`Function that can spuriously fail not wrapped in loop` | `Returned value of a sensitive function not checked`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

Standard function call with incorrect arguments

Argument to a standard function does not meet requirements for use in the function

Description

Standard function call with incorrect arguments occurs when the arguments to certain standard functions do not meet the requirements for their use in the functions.

For instance, the arguments to these functions can be invalid in the following ways.

Function Type	Situation	Risk	Fix
String manipulation functions such as `strlen` and `strcpy`	The pointer arguments do not point to a `NULL`-terminated string.	The behavior of the function is undefined.	Pass a `NULL`-terminated string to string manipulation functions.
File handling functions in `stdio.h` such as `fputc` and `fread`	The `FILE*` pointer argument can have the value `NULL`.	The behavior of the function is undefined.	Test the `FILE*` pointer for `NULL` before using it as function argument.
File handling functions in `unistd.h` such as `lseek` and `read`	The file descriptor argument can be -1.	The behavior of the function is undefined. Most implementations of the `open` function return a file descriptor value of -1. In addition, they set `errno` to indicate that an error has occurred when opening a file.	Test the return value of the `open` function for -1 before using it as argument for `read` or `lseek`. If the return value is -1, check the value of `errno` to see which error has occurred.

Function Type	Situation	Risk	Fix
	The file descriptor argument represents a closed file descriptor.	The behavior of the function is undefined.	Close the file descriptor only after you have completely finished using it. Alternatively, reopen the file descriptor before using it as function argument.
Directory name generation functions such as `mkdtemp` and `mkstemps`	The last six characters of the string template are not XXXXXX.	The function replaces the last six characters with a string that makes the file name unique. If the last six characters are not XXXXXX, the function cannot generate a unique enough directory name.	Test if the last six characters of a string are XXXXXX before using the string as function argument.
Functions related to environment variables such as `getenv` and `setenv`	The string argument is `""`.	The behavior is implementation-defined.	Test the string argument for `""` before using it as `getenv` or `setenv` argument.
	The string argument terminates with an equal sign, =. For instance, `"C="` instead of `"C"`.	The behavior is implementation-defined.	Do not terminate the string argument with =.
String handling functions such as `strtok` and `strstr`	• `strtok`: The delimiter argument is `""`. • `strstr`: The search string argument is `""`.	Some implementations do not handle these edge cases.	Test the string for `""` before using it as function argument.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

`NULL` Pointer Passed as `strnlen` Argument

```
#include <string.h>
#include <stdlib.h>

enum {
    SIZE10 = 10,
    SIZE20 = 20
};

int func() {
    char* s = NULL;
    return strnlen(s, SIZE20);
}
```

In this example, a `NULL` pointer is passed as `strnlen` argument instead of a `NULL`-terminated string.

Before running analysis on the code, specify a GNU compiler. See `Compiler (-compiler)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Correction — Pass `NULL`-terminated String

Pass a `NULL`-terminated string as the first argument of `strnlen`.

```
#include <string.h>
#include <stdlib.h>

enum {
    SIZE10 = 10,
    SIZE20 = 20
};

int func() {
    char* s = "";
    return strnlen(s, SIZE20);
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `STD_FUNC_ARG_MISMATCH`
Impact: Medium
CWE ID: 628, 685, 686, 687, 690, 910

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Buffer overflow from incorrect string format specifier

String format specifier causes buffer argument of standard library functions to overflow

Description

Buffer overflow from incorrect string format specifier occurs when the format specifier argument for functions such as `sscanf` leads to an overflow or underflow in the memory buffer argument.

Risk

If the format specifier specifies a precision that is greater than the memory buffer size, an overflow occurs. Overflows can cause unexpected behavior such as memory corruption.

Fix

Use a format specifier that is compatible with the memory buffer size.

Examples

Memory Buffer Overflow

```
#include <stdio.h>

void func (char *str[]) {
    char buf[32];
    sscanf(str[1], "%33c", buf);
}
```

In this example, `buf` can contain 32 `char` elements. Therefore, the format specifier `%33c` causes a buffer overflow.

Correction — Use Smaller Precision in Format Specifier

One possible correction is to use a smaller precision in the format specifier.

```
#include <stdio.h>

void func (char *str[]) {
    char buf[32];
    sscanf(str[1], "%32c", buf);
}
```

Result Information

Group: Static memory
Language: C | C++
Default: On
Command-Line Syntax: STR_FORMAT_BUFFER_OVERFLOW
Impact: High
CWE ID: 124, 125, 126, 127

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Invalid use of standard library string routine

Standard library string function called with invalid arguments

Description

Invalid use of standard library string routine occurs when a string library function is called with invalid arguments.

Risk

The risk depends on the type of invalid arguments. For instance, using the `strcpy` function with a source argument larger than the destination argument can result in buffer overflows.

Fix

The fix depends on the standard library function involved in the defect. In some cases, you can constrain the function arguments before the function call. For instance, if the `strcpy` function:

```
char * strcpy(char * destination, const char* source)
```

tries to copy too many bytes into the destination argument compared to the available buffer, constrain the source argument before the call to `strcpy`. In some cases, you can use an alternative function to avoid the error. For instance, instead of `strcpy`, you can use `strncpy` to control the number of bytes copied. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Invalid Use of Standard Library String Routine Error

```
#include <string.h>
#include <stdio.h>

char* Copy_String(void)
{
 char *res;
 char gbuffer[5],text[20]="ABCDEFGHIJKL";

 res=strcpy(gbuffer,text);
 /* Error: Size of text is less than gbuffer */

 return(res);
}
```

The string `text` is larger in size than `gbuffer`. Therefore, the function `strcpy` cannot copy `text` into `gbuffer`.

Correction — Use Valid Arguments

One possible correction is to declare the destination string `gbuffer` with equal or larger size than the source string `text`.

```
#include <string.h>
 #include <stdio.h>

 char* Copy_String(void)
 {
  char *res;
  /*Fix: gbuffer has equal or larger size than text */
  char gbuffer[20],text[20]="ABCDEFGHIJKL";

  res=strcpy(gbuffer,text);

  return(res);
 }
```

Check Information

Group: Static memory
Language: C | C++
Default: On
Command-Line Syntax: `STR_STD_LIB`
Impact: High
CWE ID: 120, 227, 690

See Also

`Invalid use of standard library memory routine`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Stream argument with possibly unintended side effects

Stream argument side effects occur more than once

Description

Stream argument with possibly unintended side effects occurs when you call `getc()`, `putc()`, `getwc()`, or `putwc()` with a stream argument that has side effects.

Stream argument with possibly unintended side effects considers the following as stream side effects:

- Any assignment of a variable of a stream, such as `FILE *`, or any assignment of a variable of a deeper stream type, such as an array of `FILE *`.
- Any call to a function that manipulates a stream or a deeper stream type.

The number of defects raised corresponds to the number of side effects detected. When a stream argument is evaluated multiple times in a function implemented as a macro, a defect is raised for each evaluation that has a side effect.

A defect is also raised on functions that are not implemented as macros but that can be implemented as macros on another operating system.

Risk

If the function is implemented as an unsafe macro, the stream argument can be evaluated more than once, and the stream side effect happens multiple times. For instance, a stream argument calling `fopen()` might open the same file multiple times, which is unspecified behavior.

Fix

To ensure that the side effect of a stream happens only once, use a separate statement for the stream argument.

Examples

Stream Argument of `getc()` Has Side Effect `fopen()`

```
#include <stddef.h>
#include <stdio.h>
#include <stdlib.h>

#define fatal_error() abort()

const char* myfile = "my_file.log";

void func(void)
{
    int c;
    FILE* fptr;
    /* getc() has stream argument fptr with
    * 2 side effects: call to fopen(), and assignment
    * of fptr
    */
    c = getc(fptr = fopen(myfile, "r"));
    if (c == EOF) {
        /* Handle error */
        (void)fclose(fptr);
        fatal_error();
    }
    if (fclose(fptr) == EOF) {
        /* Handle error */
        fatal_error();
    }
}

void main(void)
{
    func();

}
```

In this example, `getc()` is called with stream argument `fptr`. The stream argument has two side effects: the call to `fopen()` and the assignment of `fptr`. If `getc()` is implemented as an unsafe macro, the side effects happen multiple times.

Correction — Use Separate Statement for `fopen()`

One possible correction is to use a separate statement for `fopen()`. The call to `fopen()` and the assignment of `fptr` happen in this statement so there are no side effects when you pass `fptr` to `getc()`.

```
#include <stddef.h>
#include <stdio.h>
#include <stdlib.h>

#define fatal_error() abort()


const char* myfile = "my_file.log";

void func(void)
{
    int c;
    FILE* fptr;

    /* Separate statement for fopen()
    * before call to getc()
    */
    fptr = fopen(myfile, "r");
    if (fptr == NULL) {
        /* Handle error */
        fatal_error();
    }
    c = getc(fptr);
    if (c == EOF) {
        /* Handle error */
        (void)fclose(fptr);
        fatal_error();
    }
    if (fclose(fptr) == EOF) {
        /* Handle error */
        fatal_error();
    }
}

void main(void)
{
    func();
```

```
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `STREAM_WITH_SIDE_EFFECT`
Impact: Low

See Also

`Opening previously opened resource` | `Returned value of a sensitive function not checked` | `Standard function call with incorrect arguments`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Format string specifiers and arguments mismatch

String specifiers do not match corresponding arguments

Description

Format string specifiers and arguments mismatch occurs when the format specifiers in the formatted output functions such as `printf` do not match their corresponding arguments. For example, an argument of type `unsigned long` must have a format specification of `%lu`.

Risk

Mismatch between format specifiers and the corresponding arguments result in undefined behavior.

Fix

Make sure that the format specifiers match the corresponding arguments. For instance, in this example, the `%d` specifier does not match the string argument `message` and the `%s` specifier does not match the integer argument `err_number`.

```
const char *message = "License not available";
int err_number = ;-4
printf("Error: %d (error type %s)\n", message, err_number);
```

Switching the two format specifiers fixes the issue. See the specifications for the printf function for more information about format specifiers.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Printing a Float

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;

    printf("%d\n", fst);
}
```

In the `printf` statement, the format specifier, `%d`, does not match the data type of `fst`.

Correction — Use an Unsigned Long Format Specifier

One possible correction is to use the `%lu` format specifier. This specifier matches the `unsigned` integer type and `long` size of `fst`.

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;

    printf("%lu\n", fst);
}
```

Correction — Use an Integer Argument

One possible correction is to change the argument to match the format specifier. Convert `fst` to an integer to match the format specifier and print the value `1`.

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;

    printf("%d\n", (int)fst);
}
```

Check Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `STRING_FORMAT`
Impact: Low
CWE ID: 683, 685, 686

See Also

`Invalid use of standard library string routine`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

External Websites

Standard library output functions

Introduced in R2013b

Destination buffer overflow in string manipulation

Function writes to buffer at offset greater than buffer size

Description

Destination buffer overflow in string manipulation occurs when certain string manipulation functions write to their destination buffer argument at an offset greater than the buffer size.

For instance, when calling the function `sprintf(char* buffer, const char* format)`, you use a constant string `format` of greater size than `buffer`.

Risk

Buffer overflow can cause unexpected behavior such as memory corruption or stopping your system. Buffer overflow also introduces the risk of code injection.

Fix

One possible solution is to use alternative functions to constrain the number of characters written. For instance:

- If you use `sprintf` to write formatted data to a string, use `snprintf`, `_snprintf` or `sprintf_s` instead to enforce length control. Alternatively, use `asprintf` to automatically allocate the memory required for the destination buffer.
- If you use `vsprintf` to write formatted data from a variable argument list to a string, use `vsnprintf` or `vsprintf_s` instead to enforce length control.
- If you use `wcscpy` to copy a wide string, use `wcsncpy`, `wcslcpy`, or `wcscpy_s` instead to enforce length control.

Another possible solution is to increase the buffer size.

Examples

Buffer Overflow in `sprintf` Use

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";

    sprintf(buffer, fmt_string);
}
```

In this example, `buffer` can contain 20 `char` elements but `fmt_string` has a greater size.

Correction — Use `snprintf` Instead of `sprintf`

One possible correction is to use the `snprintf` function to enforce length control.

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";

    snprintf(buffer, 20, fmt_string);
}
```

Result Information

Group: Static memory
Language: C | C++
Default: On
Command-Line Syntax: `STRLIB_BUFFER_OVERFLOW`
Impact: High
CWE ID: 121, 125, 135, 251, 787

See Also

`Destination buffer underflow in string manipulation`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Destination buffer underflow in string manipulation

Function writes to buffer at a negative offset from beginning of buffer

Description

Destination buffer underflow in string manipulation occurs when certain string manipulation functions write to their destination buffer argument at a negative offset from the beginning of the buffer.

For instance, for the function `sprintf(char* buffer, const char* format)`, you obtain the `buffer` from an operation `buffer = (char*)arr; ... buffer += offset;`. `arr` is an array and `offset` is a negative value.

Risk

Buffer underflow can cause unexpected behavior such as memory corruption or stopping your system. Buffer underflow also introduces the risk of code injection.

Fix

If the destination buffer argument results from pointer arithmetic, see if you are decrementing a pointer. Fix the pointer decrement by modifying either the original value before decrement or the decrement value.

Examples

Buffer Underflow in `sprintf` Use

```
#include <stdio.h>
#define offset -2

void func(void) {
```

```
    char buffer[20];
    char *fmt_string ="Text";

    sprintf(&buffer[offset], fmt_string);
}
```

In this example, `&buffer[offset]` is at a negative offset from the memory allocated to `buffer`.

Correction — Change Pointer Decrementer

One possible correction is to change the value of `offset`.

```
#include <stdio.h>
#define offset 2

void func(void) {
    char buffer[20];
    char *fmt_string ="Text";

    sprintf(&buffer[offset], fmt_string);
}
```

Result Information

Group: Static memory
Language: C | C++
Default: On
Command-Line Syntax: `STRLIB_BUFFER_UNDERFLOW`
Impact: High
CWE ID: 124, 786, 787

See Also

`Destination buffer overflow in string manipulation`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Array access with tainted index

Array index from unsecure source possibly outside array bounds

Description

Array access with tainted index detects reading or writing to an array by using a tainted index that has not been validated.

Risk

The index might be outside the valid array range. If the tainted index is outside the array range, it can cause:

- Buffer underflow/underwrite — writing to memory before the beginning of the buffer.
- Buffer overflow — writing to memory after the end of a buffer.
- Over-reading a buffer — accessing memory after the end of the targeted buffer.
- Under-reading a buffer, or accessing memory before the beginning of the targeted buffer.

An attacker can use an invalid read or write operation create to problems in your program.

Fix

Before using the index to access the array, validate the index value to make sure that it is inside the array range.

Examples

Use Index to Return Buffer Value

```
#define SIZE100 100
extern int tab[SIZE100];
```

```
int taintedarrayindex(int num) {
    return tab[num];
}
```

In this example, the index `num` accesses the array `tab`. The function does not check to see if `num` is inside the range of `tab`.

Correction — Check Range Before Use

One possible correction is to check that `num` is in range before using it.

```
#define SIZE100 100
extern int tab[SIZE100];

int taintedarrayindex(int num) {
    if (num >= 0 && num < SIZE100) {
           return tab[num];
    } else {
        return -9999;
    }
}
```

Result Information

Group: Tainted Data
Language: C | C++
Default: Off
Command-Line Syntax: `TAINTED_ARRAY_INDEX`
Impact: Medium
CWE ID: 121, 124, 125, 129

See Also

`Loop bounded with tainted value` | `Pointer dereference with tainted offset` | `Tainted size of variable length array`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Use of externally controlled environment variable

Value of environment variable from an unsecure source

Description

Use of externally controlled environment variable checks for functions that add or change environment variables, such as `putenv` and `setenv`. If the new environment variable value is from an unsecure source, Polyspace raises a defect on the function or function pointer.

Risk

If the environment variable is tainted, an attacker can control your system settings. This control can disrupt an application or service in potentially malicious ways.

Fix

Before using the new environment variable, check its value to avoid giving control to external users.

Examples

Set Path in Environment

```
#define _XOPEN_SOURCE
#define _GNU_SOURCE
#include "stdlib.h"

void taintedenvvariable(char* path)
{
    putenv(path);
}
```

In this example, `putenv` changes an environment variable. The path `path` has not been checked to make sure that it is the intended path.

Correction — Sanitize Path

One possible correction is to sanitize the path, checking that it matches what you expect.

```
#define _XOPEN_SOURCE
#define _GNU_SOURCE
#define SIZE128 128
#include "stdlib.h"
#include "string.h"

/* Function to sanitize a string */
int sanitize_str(char* str, size_t n) {
    int res = 0;

    if (str && n > 0 && n < SIZE128) {
        /* string is not NULL, with size between 1 and max    */
        str[n-1] = '\0';  /* Add a null char at end of string */
        /* Tainted pointer detected above, used as "firewall" */
        res = 1;
    }
    return res;
}

void taintedenvvariable(char* path, size_t n)
{
    if (sanitize_str(path, n))
    {
        unsigned int n2 = strlen("PATH=")+strnlen(path, n);
        char *env_path = (char *)malloc(n2+1);
        if (env_path)
        {
            strcpy(env_path, "PATH=");
            strncat(env_path, path, n2);
            putenv(env_path);
        }
    }
}
```

Result Information

Group: Tainted Data
Language: C | C++
Default: Off
Command-Line Syntax: `TAINTED_ENV_VARIABLE`
Impact: Medium
CWE ID: 15

See Also

`Execution of externally controlled command` | `Host change using externally controlled elements` | `Command executed from externally controlled path` | `Library loaded from externally controlled path`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Execution of externally controlled command

Command argument from an unsecure source vulnerable to operating system command injection

Description

Execution of externally controlled command checks for commands that are fully or partially constructed from externally controlled input.

Risk

Attackers can use the externally controlled input as operating system commands, or arguments to the application. An attacker could read or modify sensitive data can be read or modified, execute unintended code, or gain access to other aspects of the program.

Fix

Validate the inputs to allow only intended input values. For example, create a whitelist of acceptable inputs and compare the input against this list.

Examples

Call Argument Command

```
#define _XOPEN_SOURCE
#define _GNU_SOURCE

#include "stdlib.h"
#include "stdio.h"
#include "string.h"
#include "unistd.h"
#include "dlfcn.h"
#include "limits.h"

enum {
```

```
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

void taintedexternalcmd(char* usercmd)
{
    char cmd[SIZE128] = "/usr/bin/cat ";
    strcat(cmd, usercmd);
    system(cmd);
}
```

This example function calls a command from a user argument without checking the command variable.

Correction — Use a Predefined Command

One possible correction is to use a `switch` statement to run a predefined command, using the user input as the switch variable.

```
#define _XOPEN_SOURCE
#define _GNU_SOURCE

#include "stdlib.h"
#include "stdio.h"
#include "string.h"
#include "unistd.h"
#include "dlfcn.h"
#include "limits.h"

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};
enum { CMD0 = 1, CMD1, CMD2 };

void taintedexternalcmd(int usercmd)
{
    char cmd[SIZE128] = "/usr/bin/cat ";

    switch(usercmd) {
        case CMD0:
            strcat(cmd, "*.c");
            break;
```

```
        case CMD1:
            strcat(cmd, "*.h");
            break;
        case CMD2:
            strcat(cmd, "*.cpp");
            break;
        default:
            strcat(cmd, "*.c");
    }
    system(cmd);
}
```

Result Information

Group: Tainted Data
Language: C | C++
Default: Off
Command-Line Syntax: `TAINTED_EXTERNAL_CMD`
Impact: Medium
CWE ID: 77, 78, 88, 114

See Also

`Use of externally controlled environment variable|Host change using externally controlled elements|Command executed from externally controlled path|Library loaded from externally controlled path|Execution of a binary from a relative path can be controlled by an external actor`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Host change using externally controlled elements

Changing host ID from an unsecure source

Description

Host change using externally controlled elements detects uncontrolled arguments in calls to routines that change the host ID, such as `sethostid` (Linux) or `SetComputerName` (Windows).

Risk

The tainted host ID value can allow external control of system settings. This control can disrupt services, cause unexpected application behavior, or cause other malicious intrusions.

Fix

Use caution when changing or editing the host ID. Do not allow user-provided values to control sensitive data.

Examples

Change Host ID from Function Argument

```
#include <unistd.h>

void bug_taintedhostid(long userhid) {
    sethostid(userhid);
}
```

This example sets a new host ID using the argument passed to the function. Before using the host ID, check the value passed in.

Correction — Predefined Host ID

One possible correction is to change the host ID to a predefined ID. This example uses the host argument as a switch variable to choose between the different, predefined host IDs.

```
#include <unistd.h>

extern long called_taintedhostid_sanitize(long);
enum { HI0 = 1, HI1, HI2, HI3 };

void taintedhostid(int host) {

    long hid = 0;
    switch(host) {
        case HI0:
            hid = 0x7f0100;
            break;
        case HI1:
            hid = 0x7f0101;
            break;
        case HI2:
            hid = 0x7f0102;
            break;
        case HI3:
            hid = 0x7f0103;
            break;
        default:
            /* do nothing */
        break;
    }
    if (hid > 0) {
        sethostid(hid);
    }
}
```

Result Information

Group: Tainted Data
Language: C | C++
Default: Off
Command-Line Syntax: `TAINTED_HOSTID`
Impact: Medium
CWE ID: 15

See Also

`Execution of externally controlled command` | `Use of externally controlled environment variable` | `Host change using externally controlled elements` | `Command executed from externally controlled path` | `Library loaded from externally controlled path`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Tainted division operand

Operands of division operation (`/`) come from an unsecure source

Description

Tainted division operand detects division operations where one or both of the integer operands is from an unsecure source.

Risk

- If the numerator is the minimum possible value and the denominator is `-1`, your division operation overflows because the result cannot be represented by the current variable size.
- If the denominator is zero, your division operation fails possibly causing your program to crash.

These risks can be used to execute arbitrary code. This code is usually outside the scope of a program's implicit security policy.

Fix

Before performing the division, validate the values of the operands. Check for denominators of `0` or `-1`, and numerators of the minimum integer value.

Examples

Division of Function Arguments

```
extern void print_int(int);

int taintedintdivision(int usernum, int userden) {
    int r =  usernum/userden;
    print_int(r);
    return r;
}
```

This example function divides two argument variables, then prints and returns the result. The argument values are unknown and can cause division by zero or integer overflow.

Correction — Check Values

One possible correction is to check the values of the numerator and denominator before performing the division.

```
#include "limits.h"

extern void print_int(int);

int taintedintdivision(int usernum, int userden) {
    int r = 0;
    if (userden!=0 && !(usernum=INT_MIN && userden==-1)) {
        r = usernum/userden;
    }
    print_int(r);
    return r;
}
```

Result Information

Group: Tainted Data
Language: C | C++
Default: Off
Command-Line Syntax: `TAINTED_INT_DIVISION`
Impact: Low
CWE ID: 189, 190, 369

See Also

`Integer division by zero` | `Float division by zero` | `Tainted modulo operand`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Tainted modulo operand

Operands of remainder operation (%) come from an unsecure source

Description

Tainted modulo operand checks the operands of remainder `%` operations. Bug Finder flags modulo operations with one or more tainted operands.

Risk

- If the second remainder operand is zero, your remainder operation fails, causing your program to crash.
- If the second remainder operand is `-1`, your remainder operation can overflow if the remainder operation is implemented based on the division operation that can overflow.
- If one of the operands is negative, the operation result is uncertain. For C89, the modulo operation is not standardized, so the result from negative operands is implementation-defined.

These risks can be exploited by attackers to gain access to your program or the target in general.

Fix

Before performing the modulo operation, validate the values of the operands. Check the second operand for values of `0` and `-1`. Check both operands for negative values.

Examples

Modulo with Function Arguments

```
extern void print_int(int);

int taintedintmod(int userden) {
    int rem =  128%userden;
```

```
    print_int(rem);
    return rem;
}
```

In this example, the function performs a modulo operation by using an input argument. The argument is not checked before calculating the remainder for values that can crash the program, such as 0 and -1.

Correction — Check Operand Values

One possible correction is to check the values of the operands before performing the modulo operation. In this corrected example, the modulo operation continues only if the second operand is greater than zero.

```
extern void print_int(int);

int taintedintmod(int userden) {
    int rem = 0;
    if (userden > 0) {
        rem = 128 % userden;
    }
    print_int(rem);
    return rem;
}
```

Result Information

Group: Tainted Data
Language: C | C++
Default: Off
Command-Line Syntax: `TAINTED_INT_MOD`
Impact: Low
CWE ID: 369, 682

See Also

`Integer division by zero` | `Tainted division operand`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Loop bounded with tainted value

Loop controlled by a value from an unsecure source

Description

Loop bounded with tainted value detects loops that are bounded by values from an unsecure source.

Risk

A tainted value can cause over looping or infinite loops. Attackers can use this vulnerability to crash your program or cause other unintended behavior.

Fix

Before starting the loop, validate unknown boundary and iterator values.

Examples

Loop Boundary From Input Argument

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int taintedloopboundary(int count) {
    int res = 0;
    for (int i=0 ; i < count; ++i) {
        res += i;
    }
    return res;
}
```

In this example, the function uses the input argument to loop `count` times. `count` could be any number because the value is not checked before starting the for-loop.

Correction — Check Loop Control

One possible correction is to check the value of the variable controlling the loop before starting the for-loop. This example checks if `count` is greater than zero and less than the maximum size.

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int taintedloopboundary(int count) {
    int res = 0;

    if (count>0 && count<SIZE128) {
        for (int i=0 ; i<count ; ++i) {
            res += i;
        }
    }
    return res;
}
```

Result Information

Group: Tainted Data
Language: C | C++
Default: Off
Command-Line Syntax: `TAINTED_LOOP_BOUNDARY`
Impact: Medium
CWE ID: 606

See Also

`Array access with tainted index` | `Pointer dereference with tainted offset`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Memory allocation with tainted size

Size argument to memory function is from an unsecure source

Description

Memory allocation with tainted size checks memory allocation functions, such as `calloc` or `malloc`, for size arguments from unsecured sources.

Risk

Uncontrolled memory allocation can cause your program to request too much system memory. This consequence can lead to a crash due to an out-of-memory condition, or assigning too many resources.

Fix

Before allocating memory, check the value of your arguments to check that they do not exceed the bounds.

Examples

Allocate Memory Using Input Argument

```
#include "stdlib.h"

int* bug_taintedmemoryallocsize(size_t size) {
    int* p = (int*)malloc(size);
    return p;
}
```

In this example, `malloc` allocates `size` amount of memory for the pointer `p`. `size` is an outside variable, so could be any size value. If the size is larger than the amount of memory you have available, your program could crash.

Correction — Check Size of Memory to be Allocated

One possible correction is to check the size of the memory that you want to allocate before performing the `malloc` operation. This example checks to see if the size is positive and less than the maximum size.

```
#include "stdlib.h"

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int* corrected_taintedmemoryallocsize(int size) {
    int* p = NULL;
    if (size>0 && size<SIZE128) {          /* Fix: Check entry range before use */
        p = (int*)malloc((unsigned int)size);
    }
    return p;
}
```

Result Information

Group: Tainted Data
Language: C | C++
Default: Off
Command-Line Syntax: `TAINTED_MEMORY_ALLOC_SIZE`
Impact: Medium
CWE ID: 128, 131, 789

See Also

`Unprotected dynamic memory allocation`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Command executed from externally controlled path

Path argument from an unsecure source

Description

Command executed from externally controlled path checks the path of commands that the application controls. If the path of a command is from or constructed from external sources, Bug Finder flags the command function.

Risk

An attacker can:

- Change the command that the program executes, possibly to a command that only the attack can control.
- Change the environment in which the command executes, by which the attacker controls what the command means and does.

Fix

Before calling the command, validate the path to make sure that it is the intended location.

Examples

Executing Path from Environment Variable

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>

enum {
```

```
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

void bug_taintedpathcmd() {
    char cmd[SIZE128] = "";
    char* userpath = getenv("MYAPP_PATH");

    strncpy(cmd, userpath, SIZE100);
    strcat(cmd, "/ls *");
    /* Launching command */
    system(cmd);
}
```

This example obtains a path from an environment variable `MYAPP_PATH`. `system` runs a command from that path without checking the value of the path. If the path is not the intended path, your program executes in the wrong location.

Correction — Use Trusted Path

One possible correction is to use a list of allowed paths to match against the environment variable path.

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

/* Function to sanitize a string */
int sanitize_str(char* s, size_t n) {
    int res = 0;
    /* String is ok if */
    if (s && n>0 && n<SIZE128) {
        /* - string is not null                      */
        /* - string has a positive and limited size */
        s[n-1] = '\0';  /* Add a security \0 char at end of string */
        /* Tainted pointer detected above, used as "firewall" */
        res = 1;
```

```
    }
    return res;
}

/* Authorized path ids */
enum { PATH0=1, PATH1, PATH2 };

void taintedpathcmd() {
    char cmd[SIZE128] = "";

    char* userpathid = getenv("MYAPP_PATH_ID");
    if (sanitize_str(userpathid, SIZE100)) {
        int pathid = atoi(userpathid);


        char path[SIZE128] = "";
        switch(pathid) {
            case PATH0:
                strcpy(path, "/usr/local/my_app0");
                break;
            case PATH1:
                strcpy(path, "/usr/local/my_app1");
                break;
            case PATH2:
                strcpy(path, "/usr/local/my_app2");
                break;
            default:
                /* do nothing */
        break;
        }
        if (strlen(path)>0) {
            strncpy(cmd, path, SIZE100);
            strcat(cmd, "/ls *");
            system(cmd);
        }
    }
}
```

Result Information

Group: Tainted Data
Language: C | C++
Default: Off

Command-Line Syntax: TAINTED_PATH_CMD
Impact: Medium
CWE ID: 114, 426

See Also

`Execution of externally controlled command` | `Use of externally controlled environment variable` | `Host change using externally controlled elements` | `Library loaded from externally controlled path`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Library loaded from externally controlled path

Using a library argument from an externally controlled path

Description

Library loaded from externally controlled path looks for libraries loaded from fixed or controlled paths. If unintended actors can control one or more locations on this fixed path, Bug Finder raises a defect.

Risk

If an attacker knows or controls the path that you use to load a library, the attacker can change:

- The library that the program loads, replacing the intended library and commands.
- The environment in which the library executes, giving unintended permissions and capabilities to the attacker.

Fix

When possible, use hard-coded or fully qualified path names to load libraries. It is possible the hard-coded paths do not work on other systems. Use a centralized location for hard-coded paths, so that you can easily modify the path within the source code.

Another solution is to use functions that require explicit paths. For example, `system()` does not require a full path because it can use the `PATH` environment variable. However, `execl()` and `execv()` do require the full path.

Examples

Call Custom Library

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include <unistd.h>
#include <dlfcn.h>
#include <limits.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

void* taintedpathlib() {
    void* libhandle = NULL;
    char lib[SIZE128] = "";
    char* userpath = getenv("LD_LIBRARY_PATH");
    strncpy(lib, userpath, SIZE128);
    strcat(lib, "/libX.so");
    libhandle = dlopen(lib, 0x00001);
    return libhandle;
}
```

This example loads the library `libX.so` from an environment variable `LD_LIBRARY_PATH`. An attacker can change the library path in this environment variable. The actual library you load could be a different library from the one that you intend.

Correction — Change and Check Path

One possible correction is to change how you get the library path and check the path of the library before opening the library. This example receives the path as an input argument. Then the path is checked to make sure the library is not under `/usr/`.

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include <unistd.h>
#include <dlfcn.h>
#include <limits.h>
```

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

/* Function to sanitize a string */
int sanitize_str(char* s, size_t n) {
    /* strlen is used here as a kind of firewall for tainted string errors */
    int res = (strlen(s) > 0 && strlen(s) < n);
    return res;
}
void* taintedpathlib(char* userpath) {
    void* libhandle = NULL;
    if (sanitize_str(userpath, SIZE128)) {
        char lib[SIZE128] = "";

        if (strncmp(userpath, "/usr", 4)!=0) {
            strncpy(lib, userpath, SIZE128);
            strcat(lib, "/libX.so");
            libhandle = dlopen(lib, RTLD_LAZY);
        }
    }
    return libhandle;
}
```

Result Information

Group: Tainted Data
Language: C | C++
Default: Off
Command-Line Syntax: TAINTED_PATH_LIB
Impact: Medium
CWE ID: 114, 426

See Also

Execution of externally controlled command | Use of externally controlled environment variable | Command executed from externally controlled path

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Use of tainted pointer

Pointer from an unsecure source may be NULL or point to unknown memory

Description

Use of tainted pointer defect is raised when:

- Tainted NULL pointer — the pointer is not validated against NULL.
- Tainted size pointer — the size of the memory zone that a pointer points to is not validated.

Note On a single pointer, your code can have instances of **Use of tainted pointer**, **Pointer dereference with tainted offset**, and **Tainted NULL or non-null-terminated string**. Bug Finder raises only the first tainted pointer defect that it finds.

Risk

An attacker can give your program a pointer that points to unexpected memory locations. If the pointer is dereferenced to write, the attacker can:

- Modify the state variables of a critical program.
- Cause your program to crash.
- Execute unwanted code.

If the pointer is dereferenced to read, the attacker can:

- Read sensitive data.
- Cause your program to crash.
- Modify a program variable to an unexpected value.

Fix

Avoid use of pointers from external sources.

Alternatively, if you trust the external source, sanitize the pointer before dereference. In a separate sanitization function:

- Check that the pointer is not NULL.
- Check the size of the memory location (if possible). This second check validates whether the size of the data the pointer points to matches the size your program expects.

The defect still appears in the body of the sanitization function. However, if you use a sanitization function, instead of several occurrences, the defect appears only once. You can justify the defect and hide it in later reviews by using code annotations. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Function That Dereferences an External Pointer

```
void taintedptr(int* p, int i) {
    *p = i;
}
```

In this example, the pointer `*p` is passed as an argument, and the value is changed. The pointer can be null or point to unknown memory, which can be vulnerable.

Correction — Avoid Use of External Pointers

One possible correction is to avoid pointers from external sources.

```
int *taintedptr(int i) {
    /* Use heap memory allocated in the application */
    int *p = (int *)malloc(sizeof (int));
    if (p != NULL) { /* Check for success */
        *p = i;
    }
return p;
}
```

Correction — Check Pointer

Another possible correction is to sanitize the pointer before using it. This example uses a second function to check if the pointer is null and can be dereferenced.

```
#include <stdlib.h>

int* sanitize_ptr(int* p) {
    int* res = NULL;
    if (p && *p) { /* Tainted pointer detected here, used as "firewall" */
        /* Pointer is not null and dereference ok */
        res = p;
    }
    return res;
}
void taintedptr(int* p, int i) {
    p = sanitize_ptr(p);
    if (p) {
        *p = i;
    }
}
```

Result Information

Group: Tainted Data
Language: C | C++
Default: Off
Command-Line Syntax: TAINTED_PTR
Impact: Low
CWE ID: 690, 822

See Also

Pointer dereference with tainted offset

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Pointer dereference with tainted offset

Offset is from an unsecure source and dereference may be out of bounds

Description

Pointer dereference with tainted offset detects pointer dereferencing, either reading or writing, using an offset variable from an unknown or unsecure source.

This check focuses on dynamically allocated buffers. For static buffer offsets, see `Array access with tainted index`.

Risk

The index might be outside the valid array range. If the tainted index is outside the array range, it can cause:

- Buffer underflow/underwrite, or writing to memory before the beginning of the buffer.
- Buffer overflow, or writing to memory after the end of a buffer.
- Over reading a buffer, or accessing memory after the end of the targeted buffer.
- Under-reading a buffer, or accessing memory before the beginning of the targeted buffer.

An attacker can use an invalid read or write to compromise your program.

Fix

Validate the index before you use the variable to access the pointer. Check to make sure that the variable is inside the valid range and does not overflow.

Examples

Dereference Pointer Array

```
#include <stdlib.h>
```

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};
extern void read_pint(int*);

int taintedptroffset(int i) {
    int* pint = (int*)calloc(SIZE10, sizeof(int));
    int c = 0;
    if(pint) {
        /* Filling array */
        read_pint(pint);
        c = pint[i];
        free(pint);
    }
    return c;
}
```

In this example, the function initializes an integer pointer `pint`. The pointer is dereferenced using the input index `i`. The value of `i` could be outside the pointer range, causing an out-of-range error.

Correction — Check Index Before Dereference

One possible correction is to validate the value of the index. If the index is inside the valid range, continue with the pointer dereferencing.

```
#include <stdlib.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};
extern void read_pint(int*);

int taintedptroffset(int i) {
    int* pint = (int*)calloc(SIZE10, sizeof(int));
    int c = 0;
    if (pint) {
        /* Filling array */
        read_pint(pint);
        if (i>0 && i<SIZE10) {
```

```
            c = pint[i];
        }
        free(pint);
    }
    return c;
}
```

Result Information

Group: Tainted Data
Language: C | C++
Default: Off
Command-Line Syntax: TAINTED_PTR_OFFSET
Impact: Low
CWE ID: 122, 124, 129, 823

See Also

`Array access with tainted index` | `Use of tainted pointer`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Tainted sign change conversion

Value from an unsecure source changes sign

Description

Tainted sign change conversion looks for values from unsecure sources that are converted, implicitly or explicitly, from signed to unsigned values.

For example, functions that use `size_t` as arguments implicitly convert the argument to an unsigned integer. Some functions that implicitly convert `size_t` are:

```
bcmp
memcpy
memmove
strncmp
strncpy
calloc
malloc
memalign
```

Risk

If you convert a small negative number to unsigned, the result is a large positive number. The large positive number can create security vulnerabilities. For example, if you use the unsigned value in:

- Memory size routines — causes allocating memory issues.
- String manipulation routines — causes buffer overflow.
- Loop boundaries — causes infinite loops.

Fix

To avoid converting unsigned negative values, check that the value being converted is within an acceptable range. For example, if the value represents a size, validate that the value is not negative and less than the maximum value size.

Examples

Set Memory Value with Size Argument

```
#include <stdlib.h>
#include <string.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

void bug_taintedsignchange(int size) {
    char str[SIZE128] = "";
    if (size<SIZE128) {
        memset(str, 'c', size);
    }
}
```

In this example, a `char` buffer is created and filled using `memset`. The size argument to `memset` is an input argument to the function.

The call to `memset` implicitly converts `size` to unsigned integer. If `size` is a large negative number, the absolute value could be too large to represent as an integer, causing a buffer overflow.

Correction — Check Value of `size`

One possible correction is to check if `size` is inside the valid range. This correction checks if `size` is greater than zero and less than the buffer size before calling `memset`.

```
#include <stdlib.h>
#include <string.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

void corrected_taintedsignchange(int size) {
    char str[SIZE128] = "";
```

```
    if (size>0 && size<SIZE128) {
        memset(str, 'c', size);
    }
}
```

Result Information

Group: Tainted Data
Language: C | C++
Default: Off
Command-Line Syntax: TAINTED_SIGN_CHANGE
Impact: Medium
CWE ID: 128, 131, 192, 194, 195

See Also

Sign change integer conversion overflow

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Tainted NULL or non-null-terminated string

Argument is from an unsecure source and may be NULL or not NULL-terminated

Description

Tainted NULL or non-null-terminated string looks for strings from unsecure sources that are being used in string manipulation routines that implicitly dereference the string buffer. For example, `strcpy` or `sprintf`.

Tainted NULL or non-null-terminated string raises no defect for a string returned from a call to `scanf`-family variadic functions. Similarly, no defect is raised when you pass the string with a `%s` specifier to `printf`-family variadic functions.

Note If you reference a string using the form `ptr[i]`, `*ptr`, or pointer arithmetic, Bug Finder raises a **Use of tainted pointer** defect instead. The **Tainted NULL or non-null-terminated string** defect is raised only when the pointer is used as a string.

Risk

If a string is from an unsecure source, it is possible that an attacker manipulated the string or pointed the string pointer to a different memory location.

If the string is NULL, the string routine cannot dereference the string, causing the program to crash. If the string is not null-terminated, the string routine might not know when the string ends. This error can cause you to write out of bounds, causing a buffer overflow.

Fix

Validate the string before you use it. Check that:

- The string is not NULL.
- The string is null-terminated
- The size of the string matches the expected size.

Examples

Getting String from Input Argument

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128

extern void print_str(const char*);

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}
```

In this example, the string `str` is concatenated with the argument `userstr`. The value of `userstr` is unknown. If the size of `userstr` is greater than the space available, the concatenation overflows.

Correction — Validate the Data

One possible correction is to check the size of `userstr` and make sure that the string is null-terminated before using it in `strncat`. This example uses a helper function, `sansitize_str`, to validate the string. The defects are concentrated in this function.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128

extern void print_str(const char*);
```

```
int sanitize_str(char* s) {
  int res = 0;
  if (s && (strlen(s) > 0)) { // TAINTED_STRING only flagged here
    // - string is not null
    // - string has a positive and limited size
    // - TAINTED_STRING on strlen used as a firewall
    res = 1;
  }
  return res;
}

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    if (sanitize_str(userstr))
      strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  if (sanitize_str(userstr))
    strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}
```

Correction — Validate the Data

Another possible correction is to call function `errorMsg` and `warningMsg` with specific strings.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128

extern void print_str(const char*);

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    strncat(str, userstr, SIZE128-(strlen(str)+1));
```

```
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}

int manageSensorValue(int sensorValue) {
  int ret = sensorValue;
  if ( sensorValue < 0 ) {
    errorMsg("sensor value should be positive");
    exit(1);
  } else if ( sensorValue > 50 ) {
    warningMsg("sensor value greater than 50 (applying threshold)...");
    sensorValue = 50;
  }

  return sensorValue;
}
```

Result Information

Group: Tainted Data
Language: C | C++
Default: Off
Command-Line Syntax: `TAINTED_STRING`
Impact: Low
CWE ID: 120, 170, 476, 690, 822

See Also

`Tainted string format`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Tainted string format

Input format argument is from an unsecure source

Description

Tainted string format detects string formatting with `printf`-style functions that contain elements from unsecure sources.

Risk

If you use externally controlled elements to format a string, you can cause buffer overflow or data-representation problems. An attacker can use these string formatting elements to view the contents of a stack using `%x` or write to a stack using `%n`.

Fix

Pass a static string to format string functions. This fix ensures that an external actor cannot control the string.

Another possible fix is to allow only the expected number of arguments. If possible, use functions that do not support the vulnerable `%n` operator in format strings.

Examples

Get Elements from User Input

```
#include "stdio.h"

void taintedstringformat(char* userstr) {
    printf(userstr);
}
```

This example prints the input argument `userstr`. The string is unknown. If it contains elements such as `%`, `printf` can interpret `userstr` as a string format instead of a string, causing your program to crash.

Correction — Print as String

One possible correction is to print `userstr` explicitly as a string so that there is no ambiguity.

```
#include "stdio.h"

void taintedstringformat(char* userstr) {
    printf("%.20s", userstr);
}
```

Result Information

Group: Tainted Data
Language: C | C++
Default: Off
Command-Line Syntax: `TAINTED_STRING_FORMAT`
Impact: Low
CWE ID: 134

See Also

`Tainted NULL or non-null-terminated string`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Tainted size of variable length array

Size of the variable-length array (VLA) is from an unsecure source and may be zero, negative, or too large

Description

Tainted size of variable length array detects variable length arrays (VLA) whose size is from an unsecure source.

Risk

If an attacker changed the size of your VLA to an unexpected value, it can cause your program to crash or behave unexpectedly.

If the size is non-positive, the behavior of the VLA is undefined. Your program does not perform as expected.

If the size is unbounded, the VLA can cause memory exhaustion or stack overflow.

Fix

Validate your VLA size to make sure that it is positive and less than a maximum value.

Examples

Input Argument Used as Size of VLA

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int taintedvlasize(int size) {
```

```
    int tabvla[size];
    int res = 0;
    for (int i=0 ; i<SIZE10 ; ++i) {
        tabvla[i] = i*i;
        res += tabvla[i];
    }
    return res;
}
```

In this example, a variable length array size is based on an input argument. Because this input argument value is not checked, the size may be negative or too large.

Correction — Check VLA Size

One possible correction is to check the size variable before creating the variable length array. This example checks if the size is larger than 10 and less than 100, before creating the VLA

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int taintedvlasize(int size) {
    int res = 0;
    if (size>SIZE10 && size<SIZE100) {
        int tabvla[size];
        for (int i=0 ; i<SIZE10 ; ++i) {
            tabvla[i] = i*i;
            res += tabvla[i];
        }
    }
    return res;
}
```

Result Information

Group: Tainted Data
Language: C | C++
Default: Off
Command-Line Syntax: `TAINTED_VLA_SIZE`

Impact: Medium
CWE ID: 128, 131, 770, 789

See Also

`Memory allocation with tainted size`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Accessing object with temporary lifetime

Read or write operations on the object are undefined behavior

Description

Accessing object with temporary lifetime occurs when you attempt to read from or write to an object with temporary lifetime that is returned by a function call. In a structure or union returned by a function, and containing an array, the array members are temporary objects. The lifetime of temporary objects ends:

- When the full expression or full declarator containing the call ends, as defined in the C11 Standard.
- After the next sequence point, as defined in the C90 and C99 Standards. A sequence point is a point in the execution of a program where all previous evaluations are complete and no subsequent evaluation has started yet.

For C++ code, **Accessing object with temporary lifetime** raises a defect only when you write to an object with a temporary lifetime.

If the temporary lifetime object is returned by address, no defect is raised.

Risk

Modifying objects with temporary lifetime is undefined behavior and can cause abnormal program termination and portability issues.

Fix

Assign the object returned from the function call to a local variable. The content of the temporary lifetime object is copied to the variable. You can now modify it safely.

Examples

Modifying Temporary Lifetime Object Returned by Function Call

```
#include <stdio.h>
#include <assert.h>
#include <stdlib.h>
#include <string.h>

#define SIZE6 6

struct S_Array
{
    int t;
    int a[SIZE6];
};

struct S_Array func_temp(void);

/* func_temp() returns a struct value containing
* an array with a temporary lifetime.
*/
int func(void) {

/*Writing to temporary lifetime object is
 undefined behavior
 */
    return ++(func_temp().a[0]);
}

void main(void) {
    (void)func();
}
```

In this example, `func_temp()` returns by value a structure with an array member `a`. This member has temporary lifetime. Incrementing it is undefined behavior.

Correction — Assign Returned Value to Local Variable Before Writing

One possible correction is to assign the return of the call to `func_temp()` to a local variable. The content of the temporary object `a` is copied to the variable, which you can safely increment.

```
 #include <stdio.h>
#include <assert.h>
#include <stdlib.h>
#include <string.h>

#define SIZE6 6

struct S_Array
{
    int t;
    int a[SIZE6];
};

struct S_Array func_temp(void);

int func(void) {

/* Assign object returned by function call to
 *local variable
 */
    struct S_Array s = func_temp();

/* Local variable can safely be
 *incremented
 */
    ++(s.a[0]);
    return s.a[0];
}

void main(void) {
    (void)func();
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: TEMP_OBJECT_ACCESS
Impact: Low
CWE ID: 825

See Also

`Large pass-by-value argument` | `Misuse of structure with flexible array member` | `Write without a further read`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Use of signal to kill thread

Uncaught signal kills entire process instead of specific thread

Description

Use of signal to kill thread occurs when you use an uncaught signal to kill a thread. For instance, you use the POSIX function `pthread_kill` and send the signal `SIGTERM` to kill a thread.

Risk

Sending a signal kills the entire process instead of just the thread that you intend to kill.

For instance, the `pthread_kill` specifications state that if the disposition of a signal is to terminate, this action affects the entire process.

Fix

Use other mechanisms that are intended to kill specific threads.

For instance, use the POSIX function `pthread_cancel` to terminate a specific thread.

Examples

Use of `pthread_kill` to Terminate Threads

```
#include <signal.h>
#include <pthread.h>

void* func(void *foo) {
  /* Execution of thread */
}

int main(void) {
  int result;
```

```
  pthread_t thread;

  if ((result = pthread_create(&thread, NULL, func, 0)) != 0) {
  }
  if ((result = pthread_kill(thread, SIGTERM)) != 0) {
  }

  /* This point is not reached because the process terminates in pthread_kill() */

  return 0;
}
```

In this example, the `pthread_kill` function sends the signal `SIGTERM` to kill a thread. The signal kills the entire process instead of the thread previously created with `pthread_create`.

Correction — Use `pthread_cancel` to Terminate Threads

One possible correction is to use the `pthread_cancel` function. The `pthread_cancel` terminates a thread specified by its first argument at a specific cancellation point or immediately, depending on the thread's cancellation type.

```
#include <signal.h>
#include <pthread.h>

void* func(void *foo) {
  /* Execution of thread */
}

int main(void) {
  int result;
  pthread_t thread;

  if ((result = pthread_create(&thread, NULL, func, 0)) != 0) {
    /* Handle Error */
  }
  if ((result = pthread_cancel(thread)) != 0) {
    /* Handle Error */
  }

  /* Continue executing */

  return 0;
}
```

See also:

- `pthread_cancel` for more information on cancellation types.
- Pthreads for functions that are allowed to be cancellation points.

Result Information

Group: Concurrency
Language: C | C++
Default: Off
Command-Line Syntax: `THREAD_KILLED_WITH_SIGNAL`
Impact: Low

See Also

`Signal call in multithreaded program`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

Thread-specific memory leak

Dynamically allocated thread-specific memory not freed before end of thread

Description

Thread-specific memory leak occurs when you do not free thread-specific dynamically allocated memory before the end of a thread.

To create thread-specific storage, you generally do these steps:

1. You create a key for thread-specific storage.
2. You create the threads.
3. In each thread, you allocate storage dynamically and then associate the key with this storage.

   After the association, you can read the stored data later using the key.
4. Before the end of the thread, you free the thread-specific memory using the key.

The checker flags execution paths in the thread where the last step is missing.

The checker works on these families of functions:

- `tss_get` and `tss_set` (C11)
- `pthread_getspecific` and `pthread_setspecific` (POSIX)

Risk

The data stored in the memory is available to other processes even after the threads end (memory leak). Besides security vulnerabilities, memory leaks can shrink the amount of available memory and reduce performance.

Fix

Free dynamically allocated memory before the end of a thread.

You can explicitly free dynamically allocated memory with functions such as `free`.

Alternatively, when you create a key, you can associate a destructor function with the key. The destructor function is called with the key value as argument at the end of a thread. In the body of the destructor function, you can free any memory associated with the key. If you use this method, Bug Finder still flags a defect. Ignore this defect with appropriate comments. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Memory Not Freed at End of Thread

```
#include <threads.h>
#include <stdlib.h>

/* Global key to the thread-specific storage */
tss_t key;
enum { MAX_THREADS = 3 };


int add_data(void) {
  int *data = (int *)malloc(2 * sizeof(int));
  if (data == NULL) {
    return -1;  /* Report error  */
  }
  data[0] = 0;
  data[1] = 1;

  if (thrd_success != tss_set(key, (void *)data)) {
    /* Handle error */
  }
  return 0;
}

void print_data(void) {
  /* Get this thread's global data from key */
  int *data = tss_get(key);

  if (data != NULL) {
    /* Print data */
  }
}

int func(void *dummy) {
```

```
  if (add_data() != 0) {
    return -1;  /* Report error */
  }
  print_data();
  return 0;
}

int main(void) {
  thrd_t thread_id[MAX_THREADS];

  /* Create the key before creating the threads */
  if (thrd_success != tss_create(&key, NULL)) {
    /* Handle error */
  }

  /* Create threads that would store specific storage */
  for (size_t i = 0; i < MAX_THREADS; i++) {
    if (thrd_success != thrd_create(&thread_id[i], func, NULL)) {
      /* Handle error */
    }
  }

  for (size_t i = 0; i < MAX_THREADS; i++) {
    if (thrd_success != thrd_join(thread_id[i], NULL)) {
      /* Handle error */
    }
  }

  tss_delete(key);
  return 0;
}
```

In this example, the start function of each thread `func` calls two functions:

- `add_data`: This function allocates storage dynamically and associates the storage with a key using the `tss_set` function.
- `print_data`: This function reads the stored data using the `tss_get` function.

At the points where `func` returns, the dynamically allocated storage has not been freed.

Correction — Free Dynamically Allocated Memory Explicitly

One possible correction is to free dynamically allocated memory explicitly before leaving the start function of a thread. See the highlighted change in the corrected version.

In this corrected version, a defect still appears on the `return` statement in the error handling section of `func`. The defect cannot occur in practice because the error handling section is entered only if dynamic memory allocation fails. Ignore this remaining defect with appropriate comments. See “Address Polyspace Results Through Bug Fixes or Comments”.

```
#include <threads.h>
#include <stdlib.h>

/* Global key to the thread-specific storage */
tss_t key;
enum { MAX_THREADS = 3 };


int add_data(void) {
  int *data = (int *)malloc(2 * sizeof(int));
  if (data == NULL) {
    return -1;  /* Report error  */
  }
  data[0] = 0;
  data[1] = 1;

  if (thrd_success != tss_set(key, (void *)data)) {
    /* Handle error */
  }
  return 0;
}

void print_data(void) {
  /* Get this thread's global data from key */
  int *data = tss_get(key);

  if (data != NULL) {
    /* Print data */
  }
}

int func(void *dummy) {
  if (add_data() != 0) {
    return -1;  /* Report error */
  }
  print_data();
  free(tss_get(key));
  return 0;
```

```
}

int main(void) {
  thrd_t thread_id[MAX_THREADS];

  /* Create the key before creating the threads */
  if (thrd_success != tss_create(&key, NULL)) {
    /* Handle error */
  }

  /* Create threads that would store specific storage */
  for (size_t i = 0; i < MAX_THREADS; i++) {
    if (thrd_success != thrd_create(&thread_id[i], func, NULL)) {
      /* Handle error */
    }
  }

  for (size_t i = 0; i < MAX_THREADS; i++) {
    if (thrd_success != thrd_join(thread_id[i], NULL)) {
      /* Handle error */
    }
  }

  tss_delete(key);
  return 0;
}
```

Result Information

Group: Concurrency
Language: C | C++
Default: Off
Command-Line Syntax: THREAD_MEM_LEAK
Impact: Medium
CWE ID: 401, 404

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”

“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

File access between time of check and use (TOCTOU)

File or folder might change state due to access race

Description

File access between time of check and use (TOCTOU) detects race condition issues between checking the existence of a file or folder, and using a file or folder.

Risk

An attacker can access and manipulate your file between your check for the file and your use of a file. Symbolic links are particularly risky because an attacker can change where your symbolic link points.

Fix

Before using a file, do not check its status. Instead, use the file and check the results afterward.

Examples

Check File Before Using

```
#include <stdio.h>
#include <fcntl.h>
#include <unistd.h>

extern void print_tofile(FILE* f);

void toctou(char * log_path) {
    if (access(log_path, W_OK)==0) {
        FILE* f = fopen(log_path, "w");
        if (f) {
```

```
            print_tofile(f);
            fclose(f);
        }
    }
}
```

In this example, before opening and using the file, the function checks if the file exists. However, an attacker can change the file between the first and second lines of the function.

Correction — Open Then Check

One possible correction is to open the file, and then check the existence and contents afterward.

```
#include <stdio.h>
#include <fcntl.h>
#include <unistd.h>

extern void print_tofile(FILE* f);

void toctou(char * log_path) {
    int fd = open(log_path, O_WRONLY);
    if (fd!=-1) {
        FILE *f = fdopen(fd, "w");
        if (f) {
            print_tofile(f);
            fclose(f);
        }
    }
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `TOCTOU`
Impact: Medium
CWE ID: 367

See Also

`Data race` | `Bad file access mode or status`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Too many va_arg calls for current argument list

Number of calls to `va_arg` exceeds number of arguments passed to variadic function

Description

Too many va_arg calls for current argument list occurs when the number of calls to `va_arg` exceeds the number of arguments passed to the corresponding variadic function. The analysis raises a defect only when the variadic function is called.

Too many va_arg calls for current argument list does not raise a defect when:

- The number of calls to `va_arg` inside the variadic function is indeterminate. For example, if the calls are from an external source.
- The `va_list` used in `va_arg` is invalid.

Risk

When you call `va_arg` and there is no next argument available in `va_list`, the behavior is undefined. The call to `va_arg` might corrupt data or return an unexpected result.

Fix

Ensure that you pass the correct number of arguments to the variadic function.

Examples

No Argument Available When Calling va_arg

```
#include <stdarg.h>
#include <stddef.h>
#include <math.h>
```

```
/* variadic function defined with
* one named argument 'count'
*/
int variadic_func(int count, ...) {
    int result = -1;
    va_list ap;
    va_start(ap, count);
    if (count > 0) {
        result = va_arg(ap, int);
        count --;
        if (count > 0) {
/* No further argument available
* in va_list when calling va_arg
*/

            result += va_arg(ap, int);
        }
    }
    va_end(ap);
    return result;
}

void func(void) {

    (void)variadic_func(2, 100);

}
```

In this example, the named argument and only one variadic argument are passed to `variadic_func()` when it is called inside `func()`. On the second call to `va_arg`, no further variadic argument is available in `ap` and the behavior is undefined.

Correction — Pass Correct Number of Arguments to Variadic Function

One possible correction is to ensure that you pass the correct number of arguments to the variadic function.

```
#include <stdarg.h>
#include <stddef.h>
#include <math.h>

/* variadic function defined with
* one named argument 'count'
*/
```

```
int variadic_func(int count, ...) {
    int result = -1;
    va_list ap;
    va_start(ap, count);
    if (count > 0) {
        result = va_arg(ap, int);
        count --;
        if (count > 0) {

/* The correct number of arguments is
* passed to va_list when variadic_func()
* is called inside func()
*/
            result += va_arg(ap, int);
        }
    }
    va_end(ap);
    return result;
}

void func(void) {

    (void)variadic_func(2, 100, 200);

}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: TOO_MANY_VA_ARG_CALLS
Impact: Medium
CWE ID: 685

See Also

`Incorrect data type passed to va_arg` | `Invalid va_list argument`

Topics

“Interpret Polyspace Bug Finder Access Results”

“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Typedef mismatch

Mismatch between `typedef` statements

Description

Typedef mismatch detects `typedef` statements with different underlying types for these fundamental types:

- `size_t`
- `ssize_t`
- `wchar_t`
- `ptrdiff_t`

Risk

If you change the underlying type of `size_t`, `ssize_t`, `wchar_t`, or `ptrdiff_t`, you have inconsistent definitions of the same type. Compilation units with different include paths can potentially use different-sized types causing conflicts in your program.

For example, say that you define a function in one compilation unit that redefines `size_t` as unsigned long. But in another compilation unit that uses the `size_t` definition from `<stddef.h>`, you use the same function as an `extern` declaration. Your program will encounter a mismatch between the function declaration and function definition.

Fix

Use consistent type definitions. For example:

- Remove custom type definitions for these fundamental types. Only use system definitions.
- Use the same size for all compilation units. Move your `typedef` to a shared header file.

Examples

Two Definitions of `size_t`

file1.c

```
typedef unsigned char size_t;

void func2()
{
    size_t var = 0;
    /*... more code ... */
}
```

file2.c

```
#include <stddef.h>

void func1()
{
    size_t var = 0;
    /*... more code ... */
}
```

In this example, Polyspace flags the definition of `size_t` in `file1.c` as a defect. This definition is a `typedef` mismatch because another file in your project, `file2.c`, includes `stddef.h`, which defines `size_t` as unsigned long.

Correction — Use System Definition

One possible correction is to use the system definition of `size_t` in `stddef.h` to avoid conflicting type definitions.

file1.c

```
#include <stddef.h>

void func2()
{
    size_t var = 0;
    /*... more code ... */
}
```

file2.c

```
#include <stddef.h>

void func1()
{
    size_t var = 0;
    /*... more code ... */
}
```

Correction — Use Shared Header File

One possible correction is to use a shared header file to store your type definition that gets included in both files.

types.h

```
typedef unsigned char size_t;
```

file1.c

```
#include "types.h"

void func2()
{
    size_t var = 0;
    /*... more code ... */
}
```

file2.c

```
#include "types.h"

void func1()
{
    size_t var = 0;
    /*... more code ... */
}
```

Result Information

Group: Programming
Language: C | C++

Default: On
Command-Line Syntax: `TYPEDEF_MISMATCH`
Impact: High

See Also

`Declaration mismatch`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2016b

Unsigned integer constant overflow

Constant value falls outside range of unsigned integer data type

Description

Unsigned integer constant overflow occurs when you assign a compile-time constant to a unsigned integer variable whose data type cannot accommodate the value. An `n`-bit unsigned integer holds values in the range `[0, 2`^{n}`-1]`.

For instance, `c` is an 8-bit unsigned `char` variable that cannot hold the value 256.

```
unsigned char c = 256;
```

To determine the sizes of fundamental types, Bug Finder uses your specification for `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

The C standard states that overflowing unsigned integers must be wrapped around (see, for instance, the C11 standard, section 6.2.5). However, the wrap-around behavior can be unintended and cause unexpected results.

Fix

Check if the constant value is what you intended. If the value is correct, use a wider data type for the variable.

Examples

Overflowing Constant from Macro Expansion

```
#define MAX_UNSIGNED_CHAR 255
#define MAX_UNSIGNED_SHORT 65535
```

```
void main() {
    unsigned char c1 = MAX_UNSIGNED_CHAR + 1;
    unsigned short c2 = MAX_UNSIGNED_SHORT + 1;
}
```

In this example, the defect appears on the macros because at least one use of the macro causes an overflow.

Correction — Use Wider Data Type

One possible correction is to use a wider data type for the variables that overflow.

```
#define MAX_UNSIGNED_CHAR 255
#define MAX_UNSIGNED_SHORT 65535

void main() {
    unsigned short c1 = MAX_UNSIGNED_CHAR + 1;
    unsigned int c2 = MAX_UNSIGNED_SHORT + 1;
}
```

Result Information

Group: Numerical
Language: C | C++
Default: Off
Command-Line Syntax: `UINT_CONSTANT_OVFL`
Impact: Low
CWE ID: 128, 189, 190, 191

See Also

`Integer constant overflow` | `Integer conversion overflow` | `Integer overflow` | `Sign change integer conversion overflow` | `Unsigned integer conversion overflow` | `Unsigned integer overflow`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018b

Unsigned integer conversion overflow

Overflow when converting between unsigned integer types

Description

Unsigned integer conversion overflow occurs when converting an unsigned integer to a smaller unsigned integer type. If the variable does not have enough bytes to represent the original constant, the conversion overflows.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Integer conversion overflows result in undefined behavior.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

You can fix the defect by:

- Using a bigger data type for the result of the conversion so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

In general, avoid conversions to smaller integer types.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Converting from `int` to `char`

```
unsigned char convert(void) {
    unsigned int unum = 1000000U;

    return (unsigned char)unum;
}
```

In the return statement, the unsigned integer variable `unum` is converted to an unsigned character type. However, the conversion overflows because 1000000 requires at least 20 bits. The C programming language standard does not view unsigned overflow as an error because the program automatically reduces the result by modulo the maximum value plus 1. In this example, `unum` is reduced by modulo `2^8` because a character data type can only represent `2^8-1`.

Correction — Change Conversion Type

One possible correction is to convert to a different integer type that can represent the entire number. For example, `long`.

```
unsigned long convert(void) {
    unsigned int unum = 1000000U;

    return (unsigned long)unum;
}
```

Check Information

Group: Numerical
Language: C | C++
Default: On
Command-Line Syntax: `UINT_CONV_OVFL`
Impact: Low
CWE ID: 128, 131, 189, 190, 191, 192, 197

See Also

`Float conversion overflow` | `Integer conversion overflow` | `Sign change integer conversion overflow`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Unsigned integer overflow

Overflow from operation between unsigned integers

Description

Unsigned integer overflow occurs when an operation on unsigned integer variables can result in values that cannot be represented by the result data type. The data type of a variable determines the number of bytes allocated for the variable storage and constrains the range of allowed values.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

The C11 standard states that unsigned integer overflows result in wrap-around behavior. However, a wrap around behavior might not always be desirable. For instance, if the result of a computation is used as an array size and the computation overflows, the array size is much smaller than expected.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

You can fix the defect by:

- Using a bigger data type for the result of the operation so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling. In the error handling code, you can override the default wrap-around behavior for overflows and implement saturation behavior, for instance.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Add One to Maximum Unsigned Integer

```
#include <limits.h>

unsigned int plusplus(void) {

    unsigned uvar = UINT_MAX;
    uvar++;
    return uvar;
}
```

In the third statement of this function, the variable `uvar` is increased by 1. However, the value of `uvar` is the maximum unsigned integer value, so 1 plus the maximum integer value cannot be represented by an `unsigned int`. The C programming language standard does not view unsigned overflow as an error because the program automatically reduces the result by modulo the maximum value plus 1. In this example, `uvar` is reduced by modulo `UINT_MAX`. The result is `uvar = 1`.

Correction — Different Storage Type

One possible correction is to store the operation result in a larger data type. In this example, by returning an `unsigned long long` instead of an `unsigned int`, the overflow error is fixed.

```
#include <limits.h>

unsigned long long plusplus(void) {

    unsigned long long ullvar = UINT_MAX;
    ullvar++;
    return ullvar;
}
```

Check Information

Group: Numerical
Language: C | C++
Default: Off
Command-Line Syntax: `UINT_OVFL`
Impact: Low
CWE ID: 128, 131, 189, 190, 191, 192

See Also

`Float overflow` | `Integer overflow`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Static uncalled function

Function with static scope not called in file

Description

Static uncalled function occurs when a `static` function is not called in the same file where it is defined.

Risk

Uncalled functions often result from legacy code and cause unnecessary maintenance.

Fix

If the function is not meant to be called, remove the function. If the function is meant for debugging purposes only, wrap the function definition in a debug macro.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Uncalled function error

Save the following code in the file `Initialize_Value.c`

```
#include <stdlib.h>
#include <stdio.h>

static int Initialize(void)
/* Defect: Function not called */
  {
   int input;
```

```
   printf("Enter an integer:");
   scanf("%d",&input);
   return(input);
  }

 void main()
  {
   int num;

   num=0;

   printf("The value of num is %d",num);
  }
```

The `static` function `Initialize` is not called in the file `Initialize_Value.c`.

Correction — Call Function at Least Once

One possible correction is to call `Initialize` at least once in the file `Initialize_Value.c`.

```
#include <stdlib.h>
#include <stdio.h>

static int Initialize(void)
  {
   int input;
   printf("Enter an integer:");
   scanf("%d",&input);
   return(input);
  }

 void main()
  {
   int num;

   /* Fix: Call static function Initialize */
   num=Initialize();

   printf("The value of num is %d",num);
  }
```

Check Information

Group: Data flow
Language: C | C++
Default: Off
Command-Line Syntax: `UNCALLED_FUNC`
Impact: Low
CWE ID: 561

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Unprotected dynamic memory allocation

Pointer returned from dynamic allocation not checked for `NULL` value

Description

Unprotected dynamic memory allocation occurs when you do not check after dynamic memory allocation whether the memory allocation succeeded.

Risk

When memory is dynamically allocated using `malloc`, `calloc`, or `realloc`, it returns a value `NULL` if the requested memory is not available. If the code following the allocation accesses the memory block without checking for this `NULL` value, this access is not protected from failures.

Fix

Check the return value of `malloc`, `calloc`, or `realloc` for NULL before accessing the allocated memory location.

```
int *ptr = malloc(size * sizeof(int));

if(ptr) /* Check for NULL */
{
   /* Memory access through ptr */
}
```

Examples

Unprotected dynamic memory allocation error

```
#include <stdlib.h>

void Assign_Value(void)
{
```

```
  int* p = (int*)calloc(5, sizeof(int));

  *p = 2;
  /* Defect: p is not checked for NULL value */

  free(p);
}
```

If the memory allocation fails, the function `calloc` returns `NULL` to `p`. Before accessing the memory through `p`, the code does not check whether `p` is `NULL`

Correction — Check for NULL Value

One possible correction is to check whether `p` has value `NULL` before dereference.

```
#include <stdlib.h>

void Assign_Value(void)
 {
   int* p = (int*)calloc(5, sizeof(int));

   /* Fix: Check if p is NULL */
   if(p!=NULL) *p = 2;

   free(p);
 }
```

Check Information

Group: Dynamic memory
Language: C | C++
Default: Off
Command-Line Syntax: `UNPROTECTED_MEMORY_ALLOCATION`
Impact: Low
CWE ID: 253, 690, 789

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”

“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Call through non-prototyped function pointer

Function pointer declared without its type or number of parameters causes unexpected behavior

Description

Call through non-prototyped function pointer detects a call to a function through a pointer without a prototype. A function prototype specifies the type and number of parameters.

Risk

Arguments passed to a function without a prototype might not match the number and type of parameters of the function definition, which can cause undefined behavior. If the parameters are restricted to a subset of their type domain, arguments from untrusted sources can trigger vulnerabilities in the called function.

Fix

Before calling the function through a pointer, provide a function prototype.

Examples

Argument Does Not Match Parameter Restriction

```
#include <stdio.h>
#include <limits.h>
#define SIZE2 2

typedef void (*func_ptr)();
extern int getchar_wrapper(void);
extern void restricted_int_sink(int i);
/* Integer value restricted to
```

```
range [-1, 255] */
extern void restricted_float_sink(double i);
/* Double value restricted to > 0.0 */



func_ptr generic_callback[SIZE2] =
{
    (func_ptr)restricted_int_sink,
    (func_ptr)restricted_float_sink
};

void func(void)
{
    int ic;
    ic = getchar_wrapper();
    /* Wrong index used for generic_callback.
    Negative 'int' passed to restricted_float_sink. */
    (*generic_callback[1])(ic);
}
```

In this example, a call through `func_ptr` passes `ic` as an argument to function `generic_callback[1]`. The type of `ic` can have negative values, while the parameter of `generic_callback[1]` is restricted to float values greater than `0.0`. Typically, compilers and static analysis tools cannot perform type checking when you do not provide a pointer prototype.

Correction — Provide Prototype of Pointer to Function

Pass the argument `ic` to a function with a parameter of type `int`, by using a properly prototyped pointer.

```
#include <stdio.h>
#include <limits.h>
#define SIZE2 2

typedef void (*func_ptr_proto)(int);
extern int getchar_wrapper(void);
extern void restricted_int_sink(int i);
/* Integer value restricted to
range [-1, 255] */
extern void restricted_float_sink(double i);
```

```
/* Double value restricted to > 0.0 */

func_ptr_proto generic_callback[SIZE2] =
{
    (func_ptr_proto)restricted_int_sink,
    (func_ptr_proto)restricted_float_sink
};

void func(void)
{
    int ic;
    ic = getchar_wrapper();
    /* ic passed to function through
properly prototyped pointer. */
    (*generic_callback[0])(ic);
}
```

Result Information

Group: Programming
Language: C
Default: On
Command-Line Syntax: `UNPROTOTYPED_FUNC_CALL`
Impact: Medium

See Also

`Declaration mismatch` | `Unreliable cast of function pointer`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Unreachable code

Code not executed because of preceding control-flow statements

Description

Unreachable code defects occur on code which cannot be reached because of a previous break in control flow.

Statements such as `break`, `goto`, and `return`, move the flow of the program to another section or function. Because of this flow escape, the statements following the control-flow code, statistically, do not execute, and therefore the statements are unreachable.

This check also finds code following trivial infinite loops, such as `while(1)`. These types of loops only release the flow of the program by exiting the program. This type of exit causes code after the infinite loop to be unreachable.

Risk

Unreachable code wastes development time, memory and execution cycles. Developers have to maintain code that is not being executed. Instructions that are not executed still have to be stored and cached.

Fix

The fix depends on the intended functionality of the unreachable code. If you want the code to be executed, check the placement of the code or the prior statement that diverts the control flow. For instance, if the unreachable code follows a `return` statement, you might have to switch their order or remove the `return` statement altogether.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Unreachable Code After Return

```
typedef enum _suit {UNKNOWN_SUIT, SPADES, HEARTS, DIAMONDS, CLUBS} suit;
suit nextcard(void);
void guess(suit s);

suit deal(void){
    suit card = nextcard();
    if( (card < SPADES) || (card > CLUBS) )
        card = UNKNOWN_SUIT;
        return card;

    if (card < HEARTS) {
        guess(card);
    }
    return card;
}
```

In this example, there are missing braces and misleading indentation. The first `return` statement changes the flow of code back to where the function was called. Because of this return statement, the `if`-block and second `return` statement do not execute.

If you correct the indentation and the braces, the error becomes clearer.

```
typedef enum _suit {UNKNOWN_SUIT, SPADES, HEARTS, DIAMONDS, CLUBS} suit;
suit nextcard(void);
void guess(suit s);

suit deal(void){
    suit card = nextcard();
    if( (card < SPADES) || (card > CLUBS) ){
        card = UNKNOWN_SUIT;
    }
    return card;

    if (card < HEARTS) {
        guess(card);
    }
    return card;
}
```

Correction — Remove Return

One possible correction is to remove the escape statement. In this example, remove the first `return` statement to reach the final `if` statement.

```
typedef enum _suit {UNKNOWN_SUIT, SPADES, HEARTS, DIAMONDS, CLUBS} suit;
suit nextcard(void);
void guess(suit s);

suit deal(void){
    suit card = nextcard();
    if( (card < SPADES) || (card > CLUBS) )
    {
        card = UNKNOWN_SUIT;
    }

    if(card < HEARTS)
    {
        guess(card);
    }
    return card;
}
```

Correction — Remove Unreachable Code

Another possible correction is to remove the unreachable code if you do not need it. Because the function does not reach the second `if`-statement, removing it simplifies the code and does not change the program behavior.

```
typedef enum _suit {UNKNOWN_SUIT, SPADES, HEARTS, DIAMONDS, CLUBS} suit;
suit nextcard(void);
void guess(suit s);

suit deal(void){
    suit card = nextcard();
    if( (card < SPADES) || (card > CLUBS) )
    {
        card = UNKNOWN_SUIT;
    }
    return card;
}
```

Infinite Loop Causing Unreachable Code

```
int add_apples(int apple) {
    int count = 1;
    while(1) {
        if(apple < 99){
            apple++;
            count++;
        }else{
            count--;
        }
    }
    return count;
}
```

In this example, the `while(1)` statement creates an infinite loop. The `return count` statement following this infinite loop is unreachable because the only way to exit this infinite loop is to exit the program.

Correction — Rewrite Loop Condition

One possible correction is to change the loop condition to make the `while` loop finite. In the example correction here, the loop uses the statement from the `if` condition: `apple < 99`.

```
int add_apples1(int apple) {
    int count = 0;
    while(apple < 99) {
        apple++;
        count++;
    }
    if(count == 0)
        count = -1;
    return count;
}
```

Correction — Add a Break Statement

Another possible correction is to add a break from the infinite loop, so there is a possibility of reaching code after the infinite loop. In this example, a `break` is added to the `else` block making the `return count` statement reachable.

```
int add_apples(int apple) {
    int count = 1;
```

```
    while(1) {
        if(apple < 99)
        {
            apple++;
            count++;
        }else{
            count--;
            break;
        }
    }
    return count;
}
```

Correction — Remove Unreachable Code

Another possible correction is to remove the unreachable code. This correction cleans up the code and makes it easier to review and maintain. In this example, remove the return statement and change the function return type to `void`.

```
void add_apples(int apple) {
    int count = 1;
    while(1) {
        if(apple < 99)
        {
            apple++;
            count++;
        }else{
            count--;
        }
    }
}
```

Check Information

Group: Data flow
Language: C | C++
Default: On
Command-Line Syntax: `UNREACHABLE`
Impact: Medium
CWE ID: 561

See Also

`Code deactivated by constant false condition` | `Dead code` | `Useless if`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Unsafe standard encryption function

Function is not reentrant or uses a risky encryption algorithm

Description

Unsafe standard encryption function detects use of functions with a broken or weak cryptographic algorithm. For example, `crypt` is not reentrant and is based on the risky Data Encryption Standard (DES).

Risk

The use of a broken, weak, or nonstandard algorithm can expose sensitive information to an attacker. A determined hacker can access the protected data using various techniques.

If the weak function is nonreentrant, when you use the function in concurrent programs, there is an additional race condition risk.

Fix

Avoid functions that use these encryption algorithms. Instead, use a reentrant function that uses a stronger encryption algorithm.

Note Some implementations of `crypt` support additional, possibly more secure, encryption algorithms.

Examples

Decrypting Password Using `crypt`

```
#define _GNU_SOURCE
#include <pwd.h>
#include <string.h>
#include <crypt.h>
```

```
volatile int rd = 1;

const char *salt = NULL;
struct crypt_data input, output;

int verif_pwd(const char *pwd, const char *cipher_pwd, int safe)
{
    int r = 0;
    char *decrypted_pwd = NULL;

    switch(safe)
    {
      case 1:
        decrypted_pwd = crypt_r(pwd, cipher_pwd, &output);
        break;

      case 2:
        decrypted_pwd = crypt_r(pwd, cipher_pwd, &output);
        break;

      default:
        decrypted_pwd = crypt(pwd, cipher_pwd);
        break;
    }

    r = (strcmp(cipher_pwd, decrypted_pwd) == 0);

    return r;
}
```

In this example, `crypt_r` and `crypt` decrypt a password. However, `crypt` is nonreentrant and uses the unsafe Data Encryption Standard algorithm.

Correction — Use `crypt_r`

One possible correction is to replace `crypt` with `crypt_r`.

```
#define _GNU_SOURCE
#include <pwd.h>
#include <string.h>
#include <crypt.h>

volatile int rd = 1;
```

```
const char *salt = NULL;
struct crypt_data input, output;

int verif_pwd(const char *pwd, const char *cipher_pwd, int safe)
{
    int r = 0;
    char *decrypted_pwd = NULL;

    switch(safe)
    {
      case 1:
        decrypted_pwd = crypt_r(pwd, cipher_pwd, &output);
        break;

      case 2:
        decrypted_pwd = crypt_r(pwd, cipher_pwd, &output);
        break;

      default:
        decrypted_pwd = crypt_r(pwd, cipher_pwd, &output);
        break;
    }

    r = (strcmp(cipher_pwd, decrypted_pwd) == 0);

    return r;
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: UNSAFE_STD_CRYPT
Impact: Medium
CWE ID: 327, 522, 663

See Also

Deterministic random output from constant seed | Predictable random output from predictable seed | Vulnerable pseudo-random number generator

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Unsafe standard function

Function unsafe for security-related purposes

Description

Unsafe standard function looks for functions that are unsafe and must not be used for security-related programming. Functions can be unsafe for many reasons. Some functions are unsafe because they are nonreentrant. Other functions change depending on the target or platform, making some implementations unsafe.

Risk

Some unsafe functions are not reentrant, meaning that the contents of the function are not locked during a call. So, an attacker can change the values midstream.

`getlogin` specifically can be unsafe depending on the implementation. Some implementations of `getlogin` return only the first eight characters of a log-in name. An attacker can use a different login with the same first eight characters to gain entry and manipulate the program.

Fix

Avoid unsafe functions for security-related purposes. If you cannot avoid unsafe functions, use a safer version of the function instead. For `getlogin`, use `getlogin_r`.

Examples

Using `getlogin`

```
#include <stdio.h>
#include <unistd.h>
#include <sys/types.h>
#include <pwd.h>
#include <string.h>
```

```
#include <stdlib.h>


volatile int rd = 1;

int login_name_check(char *user)
{
    int r = -2;
    char *name = getlogin();
    if (name != NULL)
    {
        if (strcmp(name, user) == 0)
        {
            r = 0;
        }
        else
            r = -1;
    }

    return r;
}
```

This example uses `getlogin` to compare the user name of the current user to the given user name . However, `getlogin` can return something other than the current user name because a parallel process can change the string.

Correction — Use `getlogin_r`

One possible correction is to use `getlogin_r` instead of `getlogin`. `getlogin_r` is reentrant, so you can trust the result.

```
#define _POSIX_C_SOURCE 199506L // use of getlogin_r
#include <stdio.h>
#include <unistd.h>
#include <sys/types.h>
#include <pwd.h>
#include <string.h>
#include <stdlib.h>


volatile int rd = 1;

enum {  NAME_MAX_SIZE=64  };
```

```
int login_name_check(char *user)
{
    int r;
    char name[NAME_MAX_SIZE];

    if (getlogin_r(name, sizeof(name)) == 0)
    {
        if ((strlen(user) < sizeof(name)) &&
                    (strncmp(name, user, strlen(user)) == 0))
        {
            r = 0;
        }
        else
            r = -1;
    }
    else
        r = -2;
    return r;
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: UNSAFE_STD_FUNC
Impact: Medium
CWE ID: 558, 663

See Also

`Use of obsolete standard function` | `Use of dangerous standard function` | `Invalid use of standard library string routine`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Unsafe conversion from string to numerical value

String to number conversion without validation checks

Description

Unsafe conversion from string to numerical value detects conversions from strings to integer or floating-point values. If your conversion method does not include robust error handling, a defect is raised.

Risk

Converting a string to numerical value can cause data loss or misinterpretation. Without validation of the conversion or error handling, your program continues with invalid values.

Fix

- Add additional checks to validate the numerical value.
- Use a more robust string-to-numeric conversion function such as `strtol`, `strtoll`, `strtoul`, or `strtoull`.

Examples

Conversion With `atoi`

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

static int demo_check_string_not_empty(char *s)
{
    if (s != NULL)
```

```
        return strlen(s) > 0; /* check string null-terminated and not empty */
    else
        return 0;
}

int unsafestrtonumeric(char* argv1)
{
    int s = 0;
    if (demo_check_string_not_empty(argv1))
    {
        s = atoi(argv1);
    }
    return s;
}
```

In this example, `argv1` is converted to an integer with `atoi`. `atoi` does not provide errors for an invalid integer string. The conversion can fail unexpectedly.

Correction — Use `strtol` instead

One possible correction is to use `strtol` to validate the input string and the converted integer.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <limits.h>
#include <errno.h>

static int demo_check_string_not_empty(char *s)
{
    if (s != NULL)
        return strlen(s) > 0; /* check string null-terminated and not empty */
    else
        return 0;
}

int unsafestrtonumeric(char *argv1)
{
    char *c_str = argv1;
    char *end;
    long sl;

    if (demo_check_string_not_empty(c_str))
    {
```

```
        errno = 0; /* set errno for error check */
        sl = strtol(c_str, &end, 10);
        if (end == c_str)
        {
            (void)fprintf(stderr, "%s: not a decimal number\n", c_str);
        }
        else if ('\0' != *end)
        {
            (void)fprintf(stderr, "%s: extra characters: %s\n", c_str, end);
        }
        else if ((LONG_MIN == sl || LONG_MAX == sl) && ERANGE == errno)
        {
            (void)fprintf(stderr, "%s out of range of type long\n", c_str);
        }
        else if (sl > INT_MAX)
        {
            (void)fprintf(stderr, "%ld greater than INT_MAX\n", sl);
        }
        else if (sl < INT_MIN)
        {
            (void)fprintf(stderr, "%ld less than INT_MIN\n", sl);
        }
        else
        {
            return (int)sl;
        }
    }
    return 0;
}
```

Result Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: UNSAFE_STR_TO_NUMERIC
Impact: Low
CWE ID: 20, 253, 676

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2016b

Unsafe call to a system function

Unsanitized command argument has exploitable vulnerabilities

Description

Unsafe call to a system function occurs when you use a function that invokes an implementation-defined command processor. These functions include:

- The C standard `system()` function.
- The POSIX `popen()` function.
- The Windows `_popen()` and `_wpopen()` functions.

Risk

If the argument of a function that invokes a command processor is not sanitized, it can cause exploitable vulnerabilities. An attacker can execute arbitrary commands or read and modify data anywhere on the system.

Fix

Do not use a `system`-family function to invoke a command processor. Instead, use safer functions such as POSIX `execve()` and WinAPI `CreateProcess()`.

Examples

`system()` Called

```
# include <string.h>
# include <stdlib.h>
# include <stdio.h>
# include <unistd.h>

enum {
SIZE512=512,
```

```
SIZE3=3};

void func(char *arg)
{
    char buf[SIZE512];
    int retval=sprintf(buf, "/usr/bin/any_cmd %s", arg);

    if (retval<=0 || retval>SIZE512){
        /* Handle error */
        abort();
    }
    /* Use of system() to pass any_cmd with
    unsanitized argument to command processor */

    if (system(buf) == -1) {
    /* Handle error */
  }
}
```

In this example, `system()` passes its argument to the host environment for the command processor to execute. This code is vulnerable to an attack by command-injection.

Correction — Sanitize Argument and Use `execve()`

In the following code, the argument of `any_cmd` is sanitized, and then passed to `execve()` for execution. `exec`-family functions are not vulnerable to command-injection attacks.

```
# include <string.h>
# include <stdlib.h>
# include <stdio.h>
# include <unistd.h>

enum {
SIZE512=512,
SIZE3=3};


void func(char *arg)
{
  char *const args[SIZE3] = {"any_cmd", arg, NULL};
  char  *const env[] = {NULL};

  /* Sanitize argument */
```

```
  /* Use execve() to execute any_cmd. */

  if (execve("/usr/bin/time", args, env) == -1) {
    /* Handle error */
  }
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: UNSAFE_SYSTEM_CALL
Impact: High
CWE ID: 78, 88

See Also

`Command executed from externally controlled path` | `Execution of externally controlled command`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Unused parameter

Function prototype has parameters not read or written in function body

Description

Unused parameter occurs when a function parameter is neither read nor written in the function body.

Risk

Unused function parameters cause the following issues:

- Indicate that the code is possibly incomplete. The parameter is possibly intended for an operation that you forgot to code.
- If the copied objects are large, redundant copies can slow down performance.

Fix

Determine if you intend to use the parameters. Otherwise, remove parameters that you do not use in the function body.

You can intentionally have unused parameters. For instance, you have parameters that you intend to use later when you add enhancements to the function. Add a code comment indicating your intention for later use. The code comment helps you or a code reviewer understand why your function has unused parameters.

Alternatively, add a statement such as `(void)var;` in the function body. `var` is the unused parameter. You can define a macro that expands to this statement and add the macro to the function body.

Examples

Unused Parameter

```
void func(int* xptr, int* yptr, int flag) {
    if(flag==1) {
        *xptr=0;
    }
    else {
        *xptr=1;
    }
}

int main() {
    int x,y;
    func(&x,&y,1);
    return 0;
}
```

In this example, the parameter `yptr` is not used in the body of `func`.

Correction — Use Parameter

One possible correction is to check if you intended to use the parameter. Fix your code if you intended to use the parameter.

```
void func(int* xptr, int* yptr, int flag) {
    if(flag==1) {
        *xptr=0;
        *yptr=1;
    }
    else {
        *xptr=1;
        *yptr=0;
    }
}

int main() {
    int x,y;
    func(&x,&y,1);
    return 0;
}
```

Correction — Explicitly Indicate Unused Parameter

Another possible correction is to explicitly indicate that you are aware of the unused parameter.

```
#define UNUSED(x) (void)x

void func(int* xptr, int* yptr, int flag) {
    UNUSED(yptr);
    if(flag==1) {
        *xptr=0;
    }
    else {
        *xptr=1;
    }
}

int main() {
    int x,y;
    func(&x,&y,1);
    return 0;
}
```

Result Information

Group: Good practice
Language: C | C++
Default: Off
Command-Line Syntax: `UNUSED_PARAMETER`
Impact: Low

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Useless if

Unnecessary if conditional

Description

Useless if occurs on `if`-statements where the condition is always true. This defect occurs only on if-statements that do not have an else-statement.

This defect shows unnecessary `if`-statements when there is no difference in code execution if the `if`-statement is removed.

Risk

Unnecessary `if` statements often indicate a coding error. Perhaps the `if` condition is coded incorrectly or the `if` statement is not required at all.

Fix

The fix depends on the root cause of the defect. For instance, the root cause can be an error condition that is checked twice on the same execution path, making the second check redundant.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

See examples of fixes below.

If the redundant condition represents defensive coding practices and you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

`if` with Enumerated Type

```
typedef enum _suit {UNKNOWN_SUIT, SPADES, HEARTS, DIAMONDS, CLUBS} suit;
suit nextcard(void);
void do_something(suit s);

void bridge(void)
{
    suit card = nextcard();
    if ((card < SPADES) || (card > CLUBS)){
        card = UNKNOWN_SUIT;
    }

    if (card < 7) {
        do_something(card);
    }
}
```

The type `suit` is enumerated with five options. However, the conditional expression `card < 7` always evaluates to true because `card` can be at most 5. The `if` statement is unnecessary.

Correction — Change Condition

One possible correction is to change the if-condition in the code. In this correction, the 7 is changed to `UNKNOWN_SUIT` to relate directly to the type of `card`.

```
typedef enum _suit {UNKNOWN_SUIT, SPADES, HEARTS, DIAMONDS, CLUBS} suit;
suit nextcard(void);
void do_something(suit s);

void bridge(void)
{
    suit card = nextcard();
    if ((card < SPADES) || (card > CLUBS)){
        card = UNKNOWN_SUIT;
    }

    if (card > UNKNOWN_SUIT) {
        do_something(card);
```

```
    }
}
```

Correction — Remove If

Another possible correction is to remove the if-condition in the code. Because the condition is always true, you can remove the condition to simplify your code.

```
typedef enum _suit {UNKNOWN_SUIT, SPADES, HEARTS, DIAMONDS, CLUBS} suit;
suit nextcard(void);
void do_something(suit s);

void bridge(void)
{
    suit card = nextcard();
    if ((card < SPADES) || (card > CLUBS)){
        card = UNKNOWN_SUIT;
    }

    do_something(card);
}
```

Check Information

Group: Data flow
Language: C | C++
Default: On
Command-Line Syntax: `USELESS_IF`
Impact: Medium

See Also

`Code deactivated by constant false condition` | `Dead code` | `Unreachable code`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Write without a further read

Variable never read after assignment

Description

Write without a further read occurs when a value assigned to a variable is never read.

For instance, you write a value to a variable and then write a second value before reading the previous value. The first write operation is redundant.

Risk

Redundant write operations often indicate programming errors. For instance, you forgot to read the variable between two successive write operations or unintentionally read a different variable.

Fix

Identify the reason why you write to the variable but do not read it later. Look for common programming errors such as accidentally reading a different variable with a similar name.

If you determine that the write operation is redundant, remove the operation.

Examples

Write Without Further Read Error

```
void sensor_amplification(void)
{
    extern int getsensor(void);
    int level;

    level = 4 * getsensor();
    /* Defect: Useless write */
```

```
}
```

After the variable `level` gets assigned the value `4 * getsensor()`, it is not read.

Correction — Use Value After Assignment

One possible correction is to use the variable `level` after the assignment.

```
#include <stdio.h>

void sensor_amplification(void)
{
    extern int getsensor(void);
    int level;

    level = 4 * getsensor();

    /* Fix: Use level after assignment */
    printf("The value is %d", level);

}
```

The variable `level` is printed, reading the new value.

Check Information

Group: Data flow
Language: C | C++
Default: On for handwritten code, off for generated code
Command-Line Syntax: `USELESS_WRITE`
Impact: Low
CWE ID: 398

See Also

`MISRA C:2012 Rule 2.2`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Incorrect data type passed to va_arg

Data type of variadic function argument does not match type in `va_arg` call

Description

Incorrect data type passed to va_arg when the data type in a `va_arg` call does not match the data type of the variadic function argument that `va_arg` reads.

For instance, you pass an `unsigned char` argument to a variadic function `func`. Because of default argument promotion, the argument is promoted to `int`. When you use a `va_arg` call that reads an `unsigned char` argument, a type mismatch occurs.

```
void func (int n, ...) {
   ...
   va_list args;
   va_arg(args, unsigned char);
   ...
}

void main(void) {
   unsigned char c;
   func(1,c);
}
```

Risk

In a variadic function (function with variable number of arguments), you use `va_arg` to read each argument from the variable argument list (`va_list`). The `va_arg` use does not guarantee that there actually exists an argument to read or that the argument data type matches the data type in the `va_arg` call. You have to make sure that both conditions are true.

Reading an incorrect type with a `va_arg` call can result in undefined behavior. Because function arguments reside on the stack, you might access an unwanted area of the stack.

Fix

Make sure that the data type of the argument passed to the variadic function matches the data type in the `va_arg` call.

Arguments of a variadic function undergo default argument promotions. The argument data types of a variadic function cannot be determined from a prototype. The arguments of such functions undergo default argument promotions (see Sec. 6.5.2.2 and 7.15.1.1 in the C99 Standard). Integer arguments undergo integer promotion and arguments of type `float` are promoted to `double`. For integer arguments, if a data type can be represented by an `int`, for instance, `char` or `short`, it is promoted to an `int`. Otherwise, it is promoted to an `unsigned int`. All other arguments do not undergo promotion.

To avoid undefined and implementation-defined behavior, minimize the use of variadic functions. Use the checkers for `MISRA C:2012 Rule 17.1` or `MISRA C++:2008 Rule 8-4-1` to detect use of variadic functions.

Examples

`char` Used as Function Argument Type and `va_arg` argument

```
#include <stdarg.h>
#include <stdio.h>

unsigned char func(size_t count, ...) {
    va_list ap;
    unsigned char result = 0;
    va_start(ap, count);
    if (count > 0) {
        result = va_arg(ap, unsigned char);
    }
    va_end(ap);
    return result;
}

void func_caller(void) {
    unsigned char c = 0x12;
    (void)func(1, c);
}
```

In this example, `func` takes an `unsigned char` argument, which undergoes default argument promotion to `int`. The data type in the `va_arg` call is still `unsigned char`, which does not match the `int` argument type.

Correction — Use `int` as `va_arg` Argument

One possible correction is to read an `int` argument with `va_arg`.

```
#include <stdarg.h>
#include <stdio.h>

unsigned char func(size_t count, ...) {
    va_list ap;
    unsigned char result = 0;
    va_start(ap, count);
    if (count > 0) {
        result = va_arg(ap, int);
    }
    va_end(ap);
    return result;
}

void func_caller(void) {
    unsigned char c = 0x12;
    (void)func(1, c);
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `VA_ARG_INCORRECT_TYPE`
Impact: Medium
CWE ID: 686

See Also

`Invalid va_list argument` | `Too many va_arg calls for current argument list`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2018a

Incorrect type data passed to va_start

Data type of second argument to `va_start` macro leads to undefined behavior

Description

Incorrect type data passed to va_start occurs when the second argument of the `va_start` macro has one of these data types:

- A data type that changes when undergoing default argument promotion.

  For instance, `char` and `short` undergo promotion to `int` or `unsigned int` and `float` undergoes promotion to `double`. The types `int` and `double` do not change under default argument promotion.
- (C only) A register type or a data type declared with the `register` qualifier.
- (C++ only) A reference data type.
- (C++ only) A data type that has a nontrivial copy constructor or a nontrivial move constructor.

Risk

In a variadic function or function with variable number of arguments:

```
void multipleArgumentFunction(int someArg, short rightmostFixedArg, ...) {
    va_list myList;
    va_start(myList, rightmostFixedArg);
    ...
    va_end(myList);
}
```

The `va_start` macro initializes a variable argument list so that additional arguments to the variadic function after the fixed parameters can be captured in the list. According to the C11 and C++14 Standards, if you use one of the flagged data types for the second argument of the `va_start` macro (for instance, `rightmostFixedArg` in the preceding example), the behavior is undefined.

If the data type involves a nontrivial copy constructor, the behavior is implementation-defined. For instance, whether the copy constructor is invoked in the call to `va_start` depends on the compiler.

Fix

When using the `va_start` macro, try to use the types `int`, `unsigned int` or `double` for the rightmost named parameter of the variadic function. Then, use this parameter as the second argument of the `va_start` macro.

For instance, in this example, the rightmost named parameter of the variadic function has a supported data type `int`:

```
void multipleArgumentFunction(int someArg, int rightmostFixedArg, ...) {
    va_list myList;
    va_start(myList, rightmostFixedArg);
    ...
    va_end(myList);
}
```

To avoid undefined and implementation-defined behavior, minimize the use of variadic functions. Use the checkers for `MISRA C:2012 Rule 17.1` or `MISRA C++:2008 Rule 8-4-1` to detect use of variadic functions.

Examples

Incorrect Data Types for Second Argument of `va_start`

```
#include <string>
#include <cstdarg>

double addVariableNumberOfDoubles(double* weight, short num, ...) {
    double sum=0.0;
    va_list list;
    va_start(list, num);
    for(int i=0; i < num; i++) {
        sum+=weight[i]*va_arg(list, double);
    }
    va_end(list);
    return sum;
```

```
}

double addVariableNumberOfFloats(float* weight, int num, std::string s, ...) {
    float sum=0.0;
    va_list list;
    va_start(list, s);
    for(int i=0; i < num; i++) {
        sum+=weight[i]*va_arg(list, float);
    }
    va_end(list);
    return sum;
}
```

In this example, the checker flags the call to `va_start` in:

- `addVariableNumberOfDoubles` because the argument has type `short`, which undergoes default argument promotion to `int`.
- `addVariableNumberOfFloats` because the argument has type `std::string`, which has a nontrivial copy constructor.

Correction — Fix Data Type for Second Argument of `va_start`

Make sure that the second argument of the `va_start` macro has a supported data type. In the following corrected example:

- In `addVariableNumberOfDoubles`, the data type of the last named parameter of the variadic function is changed to `int`.
- In `addVariableNumberOfFloats`, the second and third parameters of the variadic function are switched so that data type of the last named parameter is `int`.

```
#include <string>
#include <cstdarg>

double addVariableNumberOfDoubles(double* weight, int num, ...) {
    double sum=0.0;
    va_list list;
    va_start(list, num);
    for(int i=0; i < num; i++) {
        sum+=weight[i]*va_arg(list, double);
    }
    va_end(list);
    return sum;
}
```

```
double addVariableNumberOfFloats(double* weight, std::string s, int num, ...) {
    double sum=0.0;
    va_list list;
    va_start(list, num);
    for(int i=0; i < num; i++) {
        sum+=weight[i]*va_arg(list, double);
    }
    va_end(list);
    return sum;
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: VA_START_INCORRECT_TYPE
Impact: Medium

See Also

`Incorrect data type passed to va_arg` | `Incorrect use of va_start` | `Too many va_arg calls for current argument list`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2019a

Incorrect use of va_start

`va_start` is called in a non-variadic function or called with a second argument that is not the rightmost parameter of a variadic function

Description

Incorrect use of va_start occurs when you use the `va_start` macro in a way that violates its specifications.

In a variadic function or function with variable number of arguments:

```
void multipleArgumentFunction(int someArg, int rightmostFixedArg, ...) {
    va_list myList;
    va_start(myList, rightmostFixedArg);
    ...
    va_end(myList);
}
```

The `va_start` macro initializes a variable argument list so that additional arguments to the variadic function after the fixed parameters can be captured in the list. In the preceding example, the `va_start` macro initializes `myList` so that it can capture arguments after `rightmostFixedArg`.

You can violate the specifications of `va_start` in multiple ways. For instance:

- You call `va_start` in a non-variadic function.
- The second argument of `va_start` is not the rightmost fixed parameter of the variadic function.

Risk

Violating the specifications of the `va_start` macro can result in compilation errors. If the compiler fails to detect the violation, the violation can result in undefined behavior.

Fix

Make sure that:

- The `va_start` macro is used in a variadic function
- The second argument of the `va_start` macro is the rightmost fixed parameter of the variadic function.

To avoid undefined and implementation-defined behavior, minimize the use of variadic functions. Use the checkers for `MISRA C:2012 Rule 17.1` or `MISRA C++:2008 Rule 8-4-1` to detect use of variadic functions.

Examples

Incorrect Argument to `va_start`

```
#include <stdarg.h>

double addVariableNumberOfDoubles(int num, double* weight, ...) {
    double sum=0.0;
    va_list list;
    va_start(list, num);
    for(int i=0; i < num; i++) {
        sum+=weight[i]*va_arg(list, double);
    }
    va_end(list);
    return sum;
}
```

In this example, the rightmost fixed parameter to the `addVariableNumberOfDoubles` function is `weight`. However, a different parameter is used as the second argument to the `va_start` macro.

Correction — Switch Order of Fixed Parameters of Variadic Function

One possible correction is to modify the order of fixed parameters to the variadic function so that the rightmost fixed parameter is used for the `va_start` macro.

```
#include <stdarg.h>

double addVariableNumberOfDoubles(double* weight, int num, ...) {
    double sum=0.0;
    va_list list;
    va_start(list, num);
    for(int i=0; i < num; i++) {
```

```
        sum+=weight[i]*va_arg(list, double);
    }
    va_end(list);
    return sum;
}
```

Result Information

Group: Programming
Language: C | C++
Default: On
Command-Line Syntax: `VA_START_MISUSE`
Impact: Medium

See Also

`Incorrect data type passed to va_arg` | `Incorrect type data passed to va_start` | `Too many va_arg calls for current argument list`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2019a

Variable shadowing

Variable hides another variable of same name with nested scope

Description

Variable shadowing occurs when a variable hides another variable of the same name in an outer scope.

For instance, if a local variable has the same name as a global variable, the local variable hides the global variable during its lifetime.

Risk

When two variables with the same name exist in an inner and outer scope, any reference to the variable name uses the variable in the inner scope. However, a developer or reviewer might incorrectly expect that the variable in the outer scope was used.

Fix

The fix depends on the root cause of the defect. For instance, suppose you refactor a function such that you use a local static variable in place of a global variable. In this case, the global variable is redundant and you can remove its declaration. Alternatively, if you are not sure if the global variable is used elsewhere, you can modify the name of the local static variable and all references within the function.

If the shadowing is intended and you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Examples

Variable Shadowing Error

```
#include <stdio.h>
```

```
int fact[5]={1,2,6,24,120};

int factorial(int n)
 {
  int fact=1;
  /*Defect: Local variable hides global array with same name */

  for(int i=1;i<=n;i++)
    fact*=i;

  return(fact);
 }
```

Inside the `factorial` function, the integer variable `fact` hides the global integer array `fact`.

Correction — Change Variable Name

One possible correction is to change the name of one of the variables, preferably the one with more local scope.

```
#include <stdio.h>

int fact[5]={1,2,6,24,120};

int factorial(int n)
 {
  /* Fix: Change name of local variable */
  int f=1;

  for(int i=1;i<=n;i++)
    f*=i;

  return(f);
 }
```

Check Information

Group: Data flow
Language: C | C++
Default: On for handwritten code, off for generated code
Command-Line Syntax: `VAR_SHADOWING`
Impact: Low

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2013b

Incompatible types prevent overriding

Derived class method hides a `virtual` base class method instead of overriding it

Description

Incompatible types prevent overriding occurs when a derived class method has the same name and number of parameters as a `virtual` base class method but:

- Differ in at least one parameter type.
- Differ in the presence or absence of qualifiers such as `const`.

The derived class method hides the `virtual` base class method instead of overriding it.

Risk

Risks include the following:

- If you intend that the derived class method must override the base class method, the overriding does not occur.
- Because the base class method is hidden, you cannot use a derived class object to call the method. If you use a derived class object to call the method with the base class parameters, the derived class method is called instead. For the parameters whose types do not match the arguments that you pass, a cast takes place if possible. Otherwise, a compilation failure occurs.

Fix

Possible solutions include the following:

- If you want the derived class method to override the base class method, change the interface of the derived class method.

  For instance, change the parameter type or add a `const` qualifier if required.
- Otherwise, add the line `using` *`Base_class_name`*`::`*`method_name`* to the derived class declaration. In this way, you can access the base class method using an object of the derived class.

Examples

`typedef` Causing Virtual Function Hiding in Derived Class

```
class Base {
public:
    Base();
    virtual ~Base();
    virtual void func(float i);
    virtual void funcp(float* i);
    virtual void funcr(float& i);
};

typedef double Float;

class Derived: public Base {
public:
    Derived();
    ~Derived();
    void func(Float i);
    void funcp(Float* i);
    void funcr(Float& i);
};
```

In this example, because of the statement `typedef double Float;`, the `Derived` class methods `func`, `funcp` and `funcr` have `double` arguments while the `Base` class methods with the same name have `float` arguments.

Therefore, you cannot access the `Base` class methods using a `Derived` class object.

The defect appears on the method that hides a base class method. To find which base class method is hidden:

1. Navigate to the base class definition. On the **Source** pane, right-click the base class name and select **Go To Definition**.
2. In the base class definition, identify the `virtual` method that has the same name as the derived class method name.

Correction — Unhide Base Class Method

One possible correction is to use the same argument type for the base and derived class methods to enable overriding. Otherwise, if you want to call the `Base` class methods with

the `float` arguments using a `Derived` class object, add the line `using Base::`*`method_name`* to the `Derived` class declaration.

```
class Base {
public:
    Base();
    virtual ~Base();
    virtual void func(float i);
    virtual void funcp(float* i);
    virtual void funcr(float& i);
};

typedef double Float;

class Derived: public Base {
public:
    Derived();
    ~Derived();
    using Base::func;
    using Base::funcp;
    using Base::funcr;
    void func(Float i);
    void funcp(Float* i);
    void funcr(Float& i);
};
```

`const` Qualifier Missing in Derived Class Method

```
namespace Missing_Const {
class Base {
public:
    virtual void func(int) const ;
    virtual ~Base() ;
} ;

class Derived : public Base {
public:
    virtual void func(int) ;

} ;
}
```

In this example, `Derived::func` does not have a `const` qualifier but `Base::func` does. Therefore, `Derived::func` does not override `Base::func`.

Correction — Add `const` Qualifier to Derived Class Method

To enable overriding, add the `const` qualifier to the derived class method declaration.

```
namespace Missing_Const {
class Base {
public:
    virtual void func(int) const ;
    virtual ~Base() ;
} ;

class Derived : public Base {
public:
    virtual void func(int) const;

} ;
}
```

Value Instead of Reference in Derived Class Method

```
namespace Missing_Ref {

class Obj {
    int data;
};

class Base {
public:
    virtual void func(Obj& o);
    virtual ~Base() ;
} ;

class Derived : public Base {
public:
    virtual void func(Obj o) ;

} ;
}
```

In this example, `Derived::func` accepts an `Obj` parameter by value but `Base::func` accepts an `Obj` parameter by reference. Therefore, `Derived::func` does not override `Base::func`.

Correction — Use Reference for Parameter of Derived Class Method

To enable overriding, pass the derived class method parameter by reference.

```
namespace Missing_Ref {

class Obj {
    int data;
};

class Base {
public:
    virtual void func(Obj& o);
    virtual ~Base() ;
} ;

class Derived : public Base {
public:
    virtual void func(Obj& o) ;

} ;
}
```

Result Information

Group: Object oriented
Language: C++
Default: On
Command-Line Syntax: `VIRTUAL_FUNC_HIDING`
Impact: Medium

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Vulnerable pseudo-random number generator

Using a cryptographically weak pseudo-random number generator

Description

The **Vulnerable pseudo-random number generator** identifies uses of cryptographically weak pseudo-random number generator (PRNG) routines.

The list of cryptographically weak routines flagged by this checker include:

- `rand`, `random`
- `drand48`, `lrand48`, `mrand48`, `erand48`, `nrand48`, `jrand48`, and their `_r` equivalents such as `drand48_r`
- `RAND_pseudo_bytes`

Risk

These cryptographically weak routines are predictable and must not be used for security purposes. When a predictable random value controls the execution flow, your program is vulnerable to malicious attacks.

Fix

Use more cryptographically sound random number generators, such as `CryptGenRandom` (Windows), `OpenSSL/RAND_bytes`(Linux/UNIX).

Examples

Random Loop Numbers

```
#include <stdio.h>
```

```
#include <stdlib.h>

volatile int rd = 1;
int main(int argc, char *argv[])
{
    int j, r, nloops;
    struct random_data buf;
    int i = 0;

    nloops = rand();

    for (j = 0; j < nloops; j++) {
        if (random_r(&buf, &i))
            exit(1);
        printf("random_r: %ld\n", (long)i);
    }
    return 0;
}
```

This example uses `rand` and `random_r` to generate random numbers. If you use these functions for security purposes, these PRNGs can be the source of malicious attacks.

Correction — Use Stronger PRNG

One possible correction is to replace the vulnerable PRNG with a stronger random number generator.

```
#include <stdio.h>
#include <stdlib.h>
#include <openssl/rand.h>

volatile int rd = 1;
int main(int argc, char* argv[])
{
    int j, r, nloops;
    unsigned char buf;
    unsigned int seed;
    int i = 0;

    if (argc != 3)
    {
        fprintf(stderr, "Usage: %s <seed> <nloops>\n", argv[0]);
        exit(EXIT_FAILURE);
    }
```

```
    seed = atoi(argv[1]);
    nloops = atoi(argv[2]);

    for (j = 0; j < nloops; j++) {
        if (RAND_bytes(&buf, i) != 1)
            exit(1);
        printf("RAND_bytes: %u\n", (unsigned)buf);
    }
    return 0;
}
```

Result Information

Group: Security
Language: C | C++
Default: Off
Command-Line Syntax: `VULNERABLE_PRNG`
Impact: Medium
CWE ID: 330, 338

See Also

`Deterministic random output from constant seed` | `Predictable random output from predictable seed` | `Unsafe standard encryption function`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

Mismatched alloc/dealloc functions on Windows

Improper deallocation function causes memory corruption issues

Description

Mismatched alloc/dealloc functions on Windows occurs when you use a Windows deallocation function that is not properly paired to its corresponding allocation function.

Risk

Deallocating memory with a function that does not match the allocation function can cause memory corruption or undefined behavior. If you are using an older version of Windows, the improper function can also cause compatibility issues with newer versions.

Fix

Properly pair your allocation and deallocation functions according to the functions listed in this table.

Allocation Function	Deallocation Function
`malloc()`	`free()`
`realloc()`	`free()`
`calloc()`	`free()`
`_aligned_malloc()`	`_aligned_free()`
`_aligned_offset_malloc()`	`_aligned_free()`
`_aligned_realloc()`	`_aligned_free()`
`_aligned_offset_realloc()`	`_aligned_free()`
`_aligned_recalloc()`	`_aligned_free()`
`_aligned_offset_recalloc()`	`_aligned_free()`

Allocation Function	Deallocation Function
_malloca()	_freea()
LocalAlloc()	LocalFree()
LocalReAlloc()	LocalFree()
GlobalAlloc()	GlobalFree()
GlobalReAlloc()	GlobalFree()
VirtualAlloc()	VirtualFree()
VirtualAllocEx()	VirtualFreeEx()
VirtualAllocExNuma()	VirtualFreeEx()
HeapAlloc()	HeapFree()
HeapReAlloc()	HeapFree()

Examples

Memory Deallocated with Incorrect Function

```
#ifdef _WIN32_
#include <windows.h>
#else
#define _WIN32_
typedef void *HANDLE;
typedef HANDLE HGLOBAL;
typedef HANDLE HLOCAL;
typedef unsigned int UINT;
extern HLOCAL LocalAlloc(UINT uFlags, UINT uBytes);
extern HLOCAL LocalFree(HLOCAL hMem);
extern HGLOBAL GlobalFree(HGLOBAL hMem);
#endif

#define SIZE9 9


void func(void)
{
    /* Memory allocation */
    HLOCAL p = LocalAlloc(0x0000, SIZE9);
```

```
    if (p) {
        /* Memory deallocation. */
        GlobalFree(p);

    }
}
```

In this example, memory is allocated with `LocallAlloc()`. The program then erroneously uses `GlobalFree()` to deallocate the memory.

Correction — Properly Pair Windows Allocation and Deallocation Functions

When you allocate memory with `LocalAllocate()`, use `LocalFree()` to deallocate the memory.

```
#ifdef _WIN32_
#include <windows.h>
#else
#define _WIN32_
typedef void *HANDLE;
typedef HANDLE HGLOBAL;
typedef HANDLE HLOCAL;
typedef unsigned int UINT;
extern HLOCAL LocalAlloc(UINT uFlags, UINT uBytes);
extern HLOCAL LocalFree(HLOCAL hMem);
extern HGLOBAL GlobalFree(HGLOBAL hMem);
#endif

#define SIZE9 9
void func(void)
{
    /* Memory allocation */
    HLOCAL p = LocalAlloc(0x0000, SIZE9);
    if (p) {
        /* Memory deallocation. */
        LocalFree(p);
    }
}
```

Result Information

Group: Dynamic memory
Language: C | C++
Default: Off
Command-Line Syntax: `WIN_MISMATCH_DEALLOC`
Impact: Low
CWE ID: 404, 762

See Also

`Invalid deletion of pointer` | `Invalid free of pointer`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2017b

Modification of internal buffer returned from nonreentrant standard function

Function attempts to modify internal buffer returned from a nonreentrant standard function

Description

Modification of internal buffer returned from nonreentrant standard function occurs when the following happens:

- A nonreentrant standard function returns a pointer.
- You attempt to write to the memory location that the pointer points to.

Nonreentrant standard functions that return a non `const`-qualified pointer to an internal buffer include `getenv`, `getlogin`, `crypt`, `setlocale`, `localeconv`, `strerror` and others.

Risk

Modifying the internal buffer that a nonreentrant standard function returns can cause the following issues:

- It is possible that the modification does not succeed or alters other internal data.

  For instance, `getenv` returns a pointer to an environment variable value. If you modify this value, you alter the environment of the process and corrupt other internal data.
- Even if the modification succeeds, it is possible that a subsequent call to the same standard function does not return your modified value.

  For instance, you modify the environment variable value that `getenv` returns. If another process, thread, or signal handler calls `setenv`, the modified value is overwritten. Therefore, a subsequent call to `getenv` does not return your modified value.

Fix

Avoid modifying the internal buffer using the pointer returned from the function.

Examples

Modification of `getenv` Return Value

```
#include <stdlib.h>
#include <string.h>

void printstr(const char*);

void func() {
    char* env = getenv("LANGUAGE");
    if (env != NULL) {
        strncpy(env, "C", 1);
        printstr(env);
    }
}
```

In this example, the first argument of `strncpy` is the return value from a nonreentrant standard function `getenv`. The behavior can be undefined because `strncpy` modifies this argument.

Correction - Copy Return Value of `getenv` and Modify Copy

One possible solution is to copy the return value of `getenv` and pass the copy to the `strncpy` function.

```
#include <stdlib.h>
#include <string.h>
enum {
    SIZE20 = 20
};

void printstr(const char*);

void func() {
    char* env = getenv("LANGUAGE");
    if (env != NULL) {
```

```
        char env_cp[SIZE20];
        strncpy(env_cp, env, SIZE20);
        strncpy(env_cp, "C", 1);
        printstr(env_cp);
    }
}
```

Result Information

Group: Programming
Language: C | C++
Default: Off
Command-Line Syntax: `WRITE_INTERNAL_BUFFER_RETURNED_FROM_STD_FUNC`
Impact: Low
CWE ID: 573, 628

See Also

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2015b

C++ reference to const-qualified type with subsequent modification

Reference to `const`-qualified type is subsequently modified

Description

C++ reference to const-qualified type with subsequent modification occurs when a variable that refers to a `const`-qualified type is modified after declaration.

For instance, in this example, `refVal` has a type `const int &`, but its value is modified in a subsequent statement.

```
using constIntRefType = const int &;
void func(constIntRefType refVal, int val){
   ...
   refVal = val; //refVal is modified
   ...
}
```

Risk

The `const` qualifier on a reference type implies that a variable of the type is initialized at declaration and will not be subsequently modified.

Compilers can detect modification of references to `const`-qualified types as a compilation error. If the compiler does not detect the error, the behavior is undefined.

Fix

Avoid modification of `const`-qualified reference types. If the modification is required, remove the `const` qualifier from the reference type declaration.

Examples

Modification of `const`-qualified Reference Types

```
typedef const int cint;
typedef cint& ref_to_cint;

void func(ref_to_cint refVal, int initVal){
   refVal = val;
}
```

In this example, `ref_to_cint` is a reference to a `const`-qualified type. The variable `refVal` of type `ref_to_cint` is supposed to be initialized when `func` is called and not modified subsequently. The modification violates the contract implied by the `const` qualifier.

Correction — Avoid Modification of `const`-qualified Reference Types

One possible correction is to avoid the `const` in the declaration of the reference type.

```
typedef int& ref_to_int;

void func(ref_to_int refVal, int initVal){
   refVal = val;
}
```

Result Information

Group: Good practice
Language: C++
Default: Off
Command-Line Syntax: `WRITE_REFERENCE_TO_CONST_TYPE`
Impact: Low

See Also

`C++ reference type qualified with const or volatile|Qualifier removed in conversion|Writing to const qualified object`

Topics

“Interpret Polyspace Bug Finder Access Results”
“Address Polyspace Results Through Bug Fixes or Comments”

Introduced in R2019a

MISRA C 2012

MISRA C:2012 Rule 1.1

The program shall contain no violations of the standard C syntax and constraints, and shall not exceed the implementation's translation limits

Description

Rule Definition

The program shall contain no violations of the standard C syntax and constraints, and shall not exceed the implementation's translation limits.

Polyspace Implementation

The rule violation can come from multiple causes. Standard compilation error messages do not lead to a violation of this MISRA rule.

Tip To mass-justify all results that come from the same cause, use the **Detail** column on the **Results List** pane. Click the column header so that all results with the same entry are grouped together. Select the first result and then select the last result while holding the `Shift` key. Assign a status to one of the results. If you do not see the **Detail** column, right-click any other column header and enable this column.

Message in Report

- Too many nesting levels of #includes: N1. The limit is N0.

  Note: The rule checker considers a brace as an additional level. For instance, the `if` branch in this code is counted as two levels of nesting.

  ```
  if(flag) {
  }
  ```

  The metric `Number of Call Levels` counts this as one level of nesting.
- Integer constant is too large.

- ANSI C does not allow '#XX'.
- Text following preprocessing directive violates ANSI standard.
- Too many macro definitions: N1. The limit is N0.
- Array of zero size should not be used.
- Integer constant does not fit within long int.
- Integer constant does not fit within unsigned long int.
- Too many nesting levels for control flow: N1. The limit is N0.
- Assembly language should not be used.
- Too many enumeration constants: N1. The limit is N0.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Standard C Environment
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 1.2`

Introduced in R2014b

MISRA C:2012 Rule 1.2

Language extensions should not be used

Description

Rule Definition

Language extensions should not be used.

Rationale

If a program uses language extensions, its portability is reduced. Even if you document the language extensions, the documentation might not describe the behavior in all circumstances.

Polyspace Implementation

All the supported extensions lead to a violation of this MISRA rule.

Message in Report

- ANSI C90 forbids hexadecimal floating-point constants.
- ANSI C90 forbids universal character names.
- ANSI C90 forbids mixed declarations and code.
- ANSI C90/C99 forbids case ranges.
- ANSI C90/C99 forbids local label declaration.
- ANSI C90 forbids mixed declarations and code.
- ANSI C90/C99 forbids typeof operator.
- ANSI C90/C99 forbids casts to union.
- ANSI C90 forbids compound literals.
- ANSI C90/C99 forbids statements and declarations in expressions.

- ANSI C90 forbids __func__ predefined identifier.
- ANSI C90 forbids keyword '_Bool'.
- ANSI C90 forbids 'long long int' type.
- ANSI C90 forbids long long integer constants.
- ANSI C90 forbids 'long double' type.
- ANSI C90/C99 forbids 'short long int' type.
- ANSI C90 forbids _Pragma preprocessing operator.
- ANSI C90 does not allow macros with variable arguments list.
- ANSI C90 forbids designated initializer.

  Keyword 'inline' should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Standard C Environment
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 1.1`

Introduced in R2014b

MISRA C:2012 Rule 1.3

There shall be no occurrence of undefined or critical unspecified behaviour

Description

Rule Definition

There shall be no occurrence of undefined or critical unspecified behaviour.

Message in Report

There shall be no occurrence of undefined or critical unspecified behavior

- 'defined' without an identifier.
- macro 'XX' used with too few arguments.
- macro 'XX used with too many arguments.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Standard C Environment
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Dir 4.1`

Introduced in R2014b

MISRA C:2012 Rule 10.1

Operands shall not be of an inappropriate essential type

Description

Rule Definition

Operands shall not be of an inappropriate essential type.

Rationale

What Are Essential Types?

An essential type category defines the essential type of an object or expression.

Essential type category	Standard types
Essentially Boolean	`bool` or `_Bool` (defined in `stdbool.h`) If you define a boolean type through a `typedef`, you must specify this type name before coding rules checking. For more information, see `Effective boolean types (-boolean-types)`.
Essentially character	`char`
Essentially enum	named `enum`
Essentially signed	signed `char`, signed `short`, signed `int`, signed `long`, signed `long long`
Essentially unsigned	unsigned `char`, unsigned `short`, unsigned `int`, unsigned `long`, unsigned `long long`
Essentially floating	`float`, `double`, `long double`

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Amplification and Rationale

For operands of some operators, you cannot use certain essential types. In the table below, each row represents an operator/operand combination. If the essential type column is not empty for that row, there is a MISRA restriction when using that type as the operand. The number in the table corresponds to the rationale list after the table.

Operation		Essential type category of arithmetic operand					
Operator	**Operand**	**Boolean**	**character**	**enum**	**signed**	**unsigned**	**floating**
[ ]	integer	3	4				1
+ (unary)		3	4	5			
- (unary)		3	4	5		8	
+ -	either	3		5			
* /	either	3	4	5			
%	either	3	4	5			1
< > <= >=	either	3					
== !=	either						
! && ||	any		2	2	2	2	2
<< >>	left	3	4	5,6	6		1
<< >>	right	3	4	7	7		1
~ & | ^	any	3	4	5,6	6		1
?:	1st		2	2	2	2	2
?:	2nd and 3rd						

1 An expression of essentially floating type for these operands is a constraint violation.

2 When an operand is interpreted as a Boolean value, use an expression of essentially Boolean type.

3 When an operand is interpreted as a numeric value, do not use an operand of essentially Boolean type.

4 When an operand is interpreted as a numeric value, do not use an operand of essentially character type. The numeric values of character data are implementation-defined.

5 In an arithmetic operation, do not use an operand of essentially enum type. An enum object uses an implementation-defined integer type. An operation involving an enum object can therefore yield a result with an unexpected type.

6 Perform only shift and bitwise operations on operands of essentially unsigned type. When you use shift and bitwise operations on essentially signed types, the resulting numeric value is implementation-defined.

7 To avoid undefined behavior on negative shifts, use an essentially unsigned right-hand operand.

8 For the unary minus operator, do not use an operand of essentially unsigned type. The implemented size of int determines the signedness of the result.

Message in Report

The *`operand_name`* operand of the *`operator_name`* operator is of an inappropriate essential type category *`category_name`*.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Violation of Rule 10.1, Rationale 2: Inappropriate Operand Types for Operators That Take Essentially Boolean Operands

```
typedef unsigned char boolean;

extern float f32a;
extern char cha;
extern signed char s8a;
extern unsigned char u8a;
enum enuma { a1, a2, a3 } ena;

extern boolean bla, blb, rbla;

void foo(void) {
```

```
  rbla = cha && bla;        /* Non-compliant: cha is essentially char  */
  enb = ena ? a1 : a2;      /* Non-compliant: ena is essentially enum  */
  rbla = s8a && bla;        /* Non-compliant: s8a is essentially signed char  */
  ena = u8a ? a1 : a2;      /* Non-compliant: u8a is essentially unsigned char  */
  rbla = f32a && bla;       /* Non-compliant: f32a is essentially float */

  rbla = bla && blb;        /* Compliant */
  ru8a = bla ? u8a : u8b;   /* Compliant */

}
```

In the noncompliant examples, rule 10.1 is violated because:

- The operator && expects only essentially Boolean operands. However, at least one of the operands used has a different type.
- The first operand of `?:` is expected to be essentially Boolean. However, a different operand type is used.

Note For Polyspace to detect the rule violation, you must define the type name `boolean` as an effective Boolean type. For more information, see `Effective boolean types (-boolean-types)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Violation of Rule 10.1, Rationale 3: Inappropriate Boolean Operands

```
typedef unsigned char boolean;


enum enuma { a1, a2, a3 } ena;
enum { K1 = 1, K2 = 2 };    /* Essentially signed */
extern char cha, chb;
extern boolean bla, blb, rbla;
extern signed char rs8a, s8a;


void foo(void) {

  rbla = bla * blb;      /* Non-compliant - Boolean used as a numeric value */
  rbla = bla > blb;      /* Non-compliant - Boolean used as a numeric value */
```

```
  rbla = bla && blb;     /* Compliant */
  rbla = cha > chb;      /* Compliant */
  rbla = ena > a1;       /* Compliant */
  rbla = u8a > 0U;       /* Compliant */
  rs8a = K1 * s8a;       /* Compliant - K1 obtained from anonymous enum */

}
```

In the noncompliant examples, rule 10.1 is violated because the operators * and > do not expect essentially Boolean operands. However, the operands used here are essentially Boolean.

Note For Polyspace to detect the rule violation, you must define the type name `boolean` as an effective Boolean type. For more information, see `Effective boolean types (-boolean-types)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Violation of Rule 10.1, Rationale 4: Inappropriate Character Operands

```
extern char rcha, cha, chb;
extern unsigned char ru8a, u8a;

void foo(void) {

  rcha = cha & chb;      /* Non-compliant - char type used as a numeric value */
  rcha = cha << 1;       /* Non-compliant - char type used as a numeric value */

  ru8a = u8a & 2U;       /* Compliant */
  ru8a = u8a << 2U;      /* Compliant */

}
```

In the noncompliant examples, rule 10.1 is violated because the operators & and << do not expect essentially character operands. However, at least one of the operands used here has essentially character type.

Violation of Rule 10.1, Rationale 5: Inappropriate Enum Operands

```
typedef unsigned char boolean;

enum enuma { a1, a2, a3 } rena, ena, enb;

void foo(void) {

  ena--;             /* Non-Compliant - arithmetic operation with enum type*/
  rena = ena * a1;   /* Non-Compliant - arithmetic operation with enum type*/
  ena += a1;         /* Non-Compliant - arithmetic operation with enum type*/

}
```

In the noncompliant examples, rule 10.1 is violated because the arithmetic operators `--`, * and `+=` do not expect essentially enum operands. However, at least one of the operands used here has essentially enum type.

Violation of Rule 10.1, Rationale 6: Inappropriate Signed Operand for Bitwise Operations

```
extern signed char s8a;
extern unsigned char ru8a, u8a;

void foo(void) {

  ru8a = s8a & 2;       /* Non-compliant - bitwise operation on signed type */
  ru8a = 2 << 3U;       /* Non-compliant - shift operation on signed type */

  ru8a = u8a << 2U;     /* Compliant */

}
```

In the noncompliant examples, rule 10.1 is violated because the & and `<<` operations must not be performed on essentially signed operands. However, the operands used here are signed.

Violation of Rule 10.1, Rationale 7: Inappropriate Signed Right Operand for Shift Operations

```
extern signed char s8a;
extern unsigned char ru8a, u8a;

void foo(void) {

  ru8a = u8a << s8a;    /* Non-compliant - shift magnitude uses signed type */
  ru8a = u8a << -1;     /* Non-compliant - shift magnitude uses signed type */

  ru8a = u8a << 2U;     /* Compliant */
  ru8a = u8a << 1;      /* Compliant - exception */

}
```

In the noncompliant examples, rule 10.1 is violated because the operation << does not expect an essentially signed right operand. However, the right operands used here are signed.

Check Information

Group: The Essential Type Model
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 10.2

MISRA C:2012 Rule 10.2

Expressions of essentially character type shall not be used inappropriately in addition and subtraction operations

Description

Rule Definition

Expressions of essentially character type shall not be used inappropriately in addition and subtraction operations.

Rationale

Essentially character type expressions are `char` variables. Do not use character data arithmetically because the data does not represent numeric values.

Message in Report

- The *`operand_name`* operand of the + operator applied to an expression of essentially character type shall have essentially signed or unsigned type.
- The right operand of the - operator applied to an expression of essentially character type shall have essentially signed or unsigned or character type.
- The left operand of the - operator shall have essentially character type if the right operand has essentially character type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: The Essential Type Model

Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 10.1`

MISRA C:2012 Rule 10.3

The value of an expression shall not be assigned to an object with a narrower essential type or of a different essential type category

Description

Rule Definition

The value of an expression shall not be assigned to an object with a narrower essential type or of a different essential type category.

Rationale

The use of implicit conversions between types can lead to unintended results, including possible loss of value, sign, or precision.

Message in Report

- The expression is assigned to an object with a different essential type category.
- The expression is assigned to an object with a narrower essential type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: The Essential Type Model
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 10.4|MISRA C:2012 Rule 10.5|MISRA C:2012 Rule 10.6

MISRA C:2012 Rule 10.4

Both operands of an operator in which the usual arithmetic conversions are performed shall have the same essential type category

Description

Rule Definition

Both operands of an operator in which the usual arithmetic conversions are performed shall have the same essential type category.

Rationale

The use of implicit conversions between types can lead to unintended results, including possible loss of value, sign, or precision.

Polyspace Implementation

Polyspace does not produce a violation of this rule:

- If one of the operands is the constant zero.
- If one of the operands is a signed constant and the other operand is unsigned, and the signed constant has the same representation as its unsigned equivalent.

  For instance, the statement `u8b = u8a + 3;`, where `u8a` and `u8b` are `unsigned char` variables, does not violate the rule because the constants `3` and `3U` have the same representation.

Message in Report

Operands of *`operator_name`* operator shall have the same essential type category.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: The Essential Type Model
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 10.3|MISRA C:2012 Rule 10.7`

MISRA C:2012 Rule 10.5

The value of an expression should not be cast to an inappropriate essential type

Description

Rule Definition

The value of an expression should not be cast to an inappropriate essential type.

Rationale

Converting Between Variable Types

		From					
		Boolean	**character**	**enum**	**signed**	**unsigned**	**floating**
To	**Boolean**		Avoid	Avoid	Avoid	Avoid	Avoid
	character	Avoid					Avoid
	enum	Avoid	Avoid	Avoid	Avoid	Avoid	Avoid
	signed	Avoid					
	unsigned	Avoid					
	floating	Avoid	Avoid				

Some inappropriate explicit casts are:

- In C99, the result of a cast of assignment to `_Bool` is always 0 or 1. This result is not necessarily the case when casting to another type which is defined as essentially Boolean.
- A cast to an essential enum type may result in a value that does not lie within the set of enumeration constants for that type.
- A cast from essential Boolean to any other type is unlikely to be meaningful.
- Converting between floating and character types is not meaningful as there is no precise mapping between the two representations.

Some acceptable explicit casts are:

- To change the type in which a subsequent arithmetic operation is performed.
- To truncate a value deliberately.
- To make a type conversion explicit in the interests of clarity.

Message in Report

The value of an expression should not be cast to an inappropriate essential type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: The Essential Type Model
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 10.3|MISRA C:2012 Rule 10.8`

MISRA C:2012 Rule 10.6

The value of a composite expression shall not be assigned to an object with wider essential type

Description

Rule Definition

The value of a composite expression shall not be assigned to an object with wider essential type.

Rationale

A *composite expression* is a nonconstant expression using a composite operator. In the Essential Type Model, composite operators are:

- Multiplicative (`*`, `/`, `%`)
- Additive (binary `+`, binary `-`)
- Bitwise (`&`, `|`, `^`)
- Shift (`<<`, `>>`)
- Conditional (`?`, `:`)

If you assign the result of a composite expression to a larger type, the implicit conversion can result in loss of value, sign, precision, or layout.

Message in Report

The composite expression is assigned to an object with a wider essential type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: The Essential Type Model
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 10.3|MISRA C:2012 Rule 10.7`

MISRA C:2012 Rule 10.7

If a composite expression is used as one operand of an operator in which the usual arithmetic conversions are performed then the other operand shall not have wider essential type

Description

Rule Definition

If a composite expression is used as one operand of an operator in which the usual arithmetic conversions are performed, then the other operand shall not have wider essential type.

Rationale

A *composite expression* is a nonconstant expression using a composite operator. In the Essential Type Model, composite operators are:

- Multiplicative (*, /, %)
- Additive (binary +, binary -)
- Bitwise (&, |, ^)
- Shift (<<, >>)
- Conditional (?, :)

Restricting implicit conversion on composite expressions mean that sequences of arithmetic operations within expressions must use the same essential type. This restriction reduces confusion and avoids loss of value, sign, precision, or layout. However, this rule does not imply that all operands in an expression are of the same essential type.

Message in Report

- The right operand shall not have wider essential type than the left operand which is a composite expression.

- The left operand shall not have wider essential type than the right operand which is a composite expression.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: The Essential Type Model
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 10.8

The value of a composite expression shall not be cast to a different essential type category or a wider essential type

Description

Rule Definition

The value of a composite expression shall not be cast to a different essential type category or a wider essential type.

Rationale

A *composite expression* is a non-constant expression using a composite operator. In the Essential Type Model, composite operators are:

- Multiplicative (*, `/`, `%`)
- Additive (binary +, binary `-`)
- Bitwise (&, `|`, ^)
- Shift (<<, >>)
- Conditional (`?`, `:`)

Casting to a wider type is not permitted because the result may vary between implementations. Consider this expression:

```
(uint32_t) (u16a +u16b);
```

On a 16-bit machine the addition is performed in 16 bits. The result is wrapped before it is cast to 32 bits. On a 32-bit machine, the addition takes place in 32 bits and preserves high-order bits that are lost on a 16-bit machine. Casting to a narrower type with the same essential type category is acceptable as the explicit truncation of the results always leads to the same loss of information.

For information on essential types, see `MISRA C:2012 Rule 10.1`.

Polyspace Implementation

The rule checker raises a defect only if the result of a composite expression is cast to a different or wider essential type.

For instance, in this example, a violation is shown in the first assignment to `i` but not the second. In the first assignment, a composite expression `i+1` is directly cast from a signed to an unsigned type. In the second assignment, the composite expression is first cast to the same type and then the result is cast to a different type.

```
typedef int int32_T;
typedef unsigned char uint8_T;
...
...
int32_T i;
i = (uint8_T)(i+1); /* Noncompliant */
i = (uint8_T)((int32_T)(i+1)); /* Compliant */
```

Message in Report

- The value of a composite expression shall not be cast to a different essential type category.
- The value of a composite expression shall not be cast to a wider essential type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Casting to Different or Wider Essential Type

```
extern unsigned short ru16a, u16a, u16b;
extern unsigned int   u32a, ru32a;
extern signed int     s32a, s32b;

void foo(void)
{
```

```
  ru16a  = (unsigned short) (u32a + u32a);/* Compliant                          */
  ru16a += (unsigned short) s32a;    /* Compliant - s32a is not composite       */
  ru32a  = (unsigned int) (u16a + u16b);  /* Noncompliant - wider essential type */
}
```

In this example, rule 10.8 is violated in the following cases:

- `s32a` and `s32b` are essentially `signed` variables. However, the result `( s32a + s32b )` is cast to an essentially `unsigned` type.
- `u16a` and `u16b` are essentially `unsigned short` variables. However, the result `( s32a + s32b )` is cast to a wider essential type, `unsigned int`.

Check Information

Group: The Essential Type Model
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 10.5`

MISRA C:2012 Rule 11.1

Conversions shall not be performed between a pointer to a function and any other type

Description

Rule Definition

Conversions shall not be performed between a pointer to a function and any other type.

Rationale

The rule forbids the following two conversions:

- Conversion from a function pointer to any other type. This conversion causes undefined behavior.
- Conversion from a function pointer to another function pointer, if the function pointers have different argument and return types.

  The conversion is forbidden because calling a function through a pointer with incompatible type results in undefined behavior.

Polyspace Implementation

Polyspace considers both explicit and implicit casts when checking this rule. However, casts from `NULL` or `(void*)0` do not violate this rule.

Message in Report

Conversions shall not be performed between a pointer to a function and any other type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Cast between two function pointers

```
typedef void (*fp16) (short n);
typedef void (*fp32) (int n);

#include <stdlib.h>                     /* To obtain macro  NULL */

void func(void) {   /* Exception 1 - Can convert a null pointer
                     * constant into a pointer to a function */
  fp16 fp1 = NULL;                  /* Compliant - exception  */
  fp16 fp2 = (fp16) fp1;            /* Compliant */
  fp32 fp3 = (fp32) fp1;            /* Non-compliant */
  if (fp2 != NULL) {}               /* Compliant - exception  */
  fp16 fp4 = (fp16) 0x8000;         /* Non-compliant - integer to
                                     * function pointer */}
```

In this example, the rule is violated when:

- The pointer `fp1` of type `fp16` is cast to type `fp32`. The function pointer types `fp16` and `fp32` have different argument types.
- An integer is cast to type `fp16`.

The rule is not violated when function pointers `fp1` and `fp2` are cast to `NULL`.

Check Information

Group: Pointer Type Conversions
Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 11.2

Conversions shall not be performed between a pointer to an incomplete type and any other type

Description

Rule Definition

Conversions shall not be performed between a pointer to an incomplete type and any other type.

Rationale

An incomplete type is a type that does not contain sufficient information to determine its size. For example, the statement `struct s;` describes an incomplete type because the fields of `s` are not defined. The size of a variable of type `s` cannot be determined.

Conversions to or from a pointer to an incomplete type result in undefined behavior. Typically, a pointer to an incomplete type is used to hide the full representation of an object. This encapsulation is broken if another pointer is implicitly or explicitly cast to such a pointer.

Message in Report

Conversions shall not be performed between a pointer to an incomplete type and any other type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Casts from incomplete type

```
struct s *sp;
struct t *tp;
short  *ip;
struct ct *ctp1;
struct ct *ctp2;


void foo(void) {

    ip = (short *) sp;            /* Non-compliant */
    sp = (struct s *) 1234;       /* Non-compliant */
    tp = (struct t *) sp;         /* Non-compliant */
    ctp1 = (struct ct *) ctp2;    /* Compliant */

    /* You can convert a null pointer constant to
     * a pointer to an incomplete type */
    sp = NULL;                    /* Compliant - exception  */

    /* A pointer to an incomplete type may be converted into void */
    struct s *f(void);
    (void) f();                   /* Compliant - exception  */

}
```

In this example, types `s`, `t` and `ct` are incomplete. The rule is violated when:

- The variable `sp` with an incomplete type is cast to a basic type.
- The variable `sp` with an incomplete type is cast to a different incomplete type `t`.

The rule is not violated when:

- The variable `ctp2` with an incomplete type is cast to the same incomplete type.
- The `NULL` pointer is cast to the variable `sp` with an incomplete type.
- The return value of `f` with incomplete type is cast to `void`.

Check Information

Group: Pointer Type Conversions
Category: Required
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Rule 11.5

Introduced in R2014b

MISRA C:2012 Rule 11.3

A cast shall not be performed between a pointer to object type and a pointer to a different object type

Description

Rule Definition

A cast shall not be performed between a pointer to object type and a pointer to a different object type.

Rationale

If a pointer to an object is cast into a pointer to a different object, the resulting pointer can be incorrectly aligned. The incorrect alignment causes undefined behavior.

Even if the conversion produces a pointer that is correctly aligned, the behavior can be undefined if the pointer is used to access an object.

Exception: You can convert a pointer to object type into a pointer to one of the following types:

- `char`
- `signed char`
- `unsigned char`

Message in Report

A cast shall not be performed between a pointer to object type and a pointer to a different object type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Noncompliant: Cast to Pointer Pointing to Object of Wider Type

```
signed   char *p1;
unsigned int *p2;

void foo(void){
  p2 = ( unsigned int * ) p1;     /* Non-compliant */
}
```

In this example, `p1` can point to a `signed char` object. However, `p1` is cast to a pointer that points to an object of wider type, `unsigned int`.

Noncompliant: Cast to Pointer Pointing to Object of Narrower Type

```
extern unsigned int read_value ( void );
extern void display ( unsigned int n );

void foo ( void ){
  unsigned int u = read_value ( );
  unsigned short *hi_p = ( unsigned short * ) &u;    /* Non-compliant  */
  *hi_p = 0;
  display ( u );
}
```

In this example, `u` is an `unsigned int` variable. `&u` is cast to a pointer that points to an object of narrower type, `unsigned short`.

On a big-endian machine, the statement `*hi_p = 0` attempts to clear the high bits of the memory location that `&u` points to. But, from the result of `display(u)`, you might find that the high bits have not been cleared.

Compliant: Cast Adding a Type Qualifier

```
const short *p;
const volatile short *q;
void foo (void){
```

```
  q = ( const volatile short * ) p;  /* Compliant */
}
```

In this example, both `p` and `q` can point to `short` objects. The cast between them adds a `volatile` qualifier only and is therefore compliant.

Check Information

Group: Pointer Type Conversions
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 11.4` | `MISRA C:2012 Rule 11.5` | `MISRA C:2012 Rule 11.8`

Introduced in R2014b

MISRA C:2012 Rule 11.4

A conversion should not be performed between a pointer to object and an integer type

Description

Rule Definition

A conversion should not be performed between a pointer to object and an integer type.

Rationale

Conversion between integers and pointers can cause errors or undefined behavior.

- If an integer is cast to a pointer, the resulting pointer can be incorrectly aligned. The incorrect alignment causes undefined behavior.
- If a pointer is cast to an integer, the resulting value can be outside the allowed range for the integer type.

Polyspace Implementation

Casts or implicit conversions from `NULL` or `(void*)0` do not generate a warning.

Message in Report

A conversion should not be performed between a pointer to object and an integer type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Casts between pointer and integer

```
#include <stdbool.h>

typedef unsigned char      uint8_t;
typedef          char      char_t;
typedef unsigned short     uint16_t;
typedef signed   int       int32_t;

typedef _Bool bool_t;
uint8_t *PORTA = (uint8_t *) 0x0002;            /* Non-compliant */

void foo(void) {

    char_t c = 1;
    char_t *pc = &c;                              /* Compliant */


    uint16_t ui16   = 7U;
    uint16_t *pui16 = &ui16;                      /* Compliant */
    pui16 = (uint16_t *) ui16;                    /* Non-compliant */


    uint16_t *p;
    int32_t addr = (int32_t) p;                  /* Non-compliant */
    bool_t b = (bool_t) p;                       /* Non-compliant */
    enum etag { A, B } e = ( enum etag ) p;      /* Non-compliant */
}
```

In this example, the rule is violated when:

- The integer `0x0002` is cast to a pointer.

  If the integer defines an absolute address, it is more common to assign the address to a pointer in a header file. To avoid the assignment being flagged, you can then exclude headers files from coding rules checking. For more information, see `Do not generate results for (-do-not-generate-results-for)Do not generate results for (-do-not-generate-results-for)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

- The pointer `p` is cast to integer types such as `int32_t`, `bool_t` or `enum etag`.

The rule is not violated when the address `&ui16` is assigned to a pointer.

Check Information

Group: Pointer Type Conversions
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 11.3|MISRA C:2012 Rule 11.7|MISRA C:2012 Rule 11.9`

Introduced in R2014b

MISRA C:2012 Rule 11.5

A conversion should not be performed from pointer to void into pointer to object

Description

Rule Definition

A conversion should not be performed from pointer to void into pointer to object.

Rationale

If a pointer to `void` is cast into a pointer to an object, the resulting pointer can be incorrectly aligned. The incorrect alignment causes undefined behavior. However, such a cast can sometimes be necessary, for example, when using memory allocation functions.

Polyspace Implementation

Casts or implicit conversions from `NULL` or `(void*)0` do not generate a warning.

Message in Report

A conversion should not be performed from pointer to void into pointer to object.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Cast from Pointer to `void`

```
void foo(void) {
```

```
    unsigned int  u32a = 0;
    unsigned int  *p32 = &u32a;
    void          *p;
    unsigned int  *p16;

    p   = p32;                /* Compliant - pointer to uint32_t
                               *            into pointer to void */
    p16 = p;                  /* Non-compliant */

    p   = (void *) p16;       /* Compliant */
    p32 = (unsigned int *) p; /* Non-compliant */
}
```

In this example, the rule is violated when the pointer `p` of type `void*` is cast to pointers to other types.

The rule is not violated when `p16` and `p32`, which are pointers to non-`void` types, are cast to `void*`.

Check Information

Group: Pointer Type Conversions
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 11.2|MISRA C:2012 Rule 11.3`

Introduced in R2014b

MISRA C:2012 Rule 11.6

A cast shall not be performed between pointer to void and an arithmetic type

Description

Rule Definition

A cast shall not be performed between pointer to void and an arithmetic type.

Rationale

Conversion between integer types and pointers to `void` can cause errors or undefined behavior.

- If an integer type is cast to a pointer, the resulting pointer can be incorrectly aligned. The incorrect alignment causes undefined behavior.
- If a pointer is cast to an arithmetic type, the resulting value can be outside the allowed range for the type.

Conversion between non-integer arithmetic types and pointers to `void` is undefined.

Polyspace Implementation

Casts or implicit conversions from `NULL` or `(void*)0` do not generate a warning.

Message in Report

A cast shall not be performed between pointer to void and an arithmetic type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Casts Between Pointer to `void` and Arithmetic Types

```
void foo(void) {

    void          *p;
    unsigned int  u;
    unsigned short r;

    p = (void *) 0x1234u;            /* Non-compliant - undefined */
    u = (unsigned int) p;            /* Non-compliant - undefined */

    p = (void *) 0;                  /* Compliant - Exception */

}
```

In this example, `p` is a pointer to `void`. The rule is violated when:

- An integer value is cast to `p`.
- `p` is cast to an `unsigned int` type.

The rule is not violated if an integer constant with value 0 is cast to a pointer to `void`.

Check Information

Group: Pointer Type Conversions
Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 11.7

A cast shall not be performed between pointer to object and a non-integer arithmetic type

Description

Rule Definition

A cast shall not be performed between pointer to object and a non-integer arithmetic type.

Rationale

This rule covers types that are essentially Boolean, character, enum or floating.

- If an essentially Boolean, character or enum variable is cast to a pointer, the resulting pointer can be incorrectly aligned. The incorrect alignment causes undefined behavior. If a pointer is cast to one of those types, the resulting value can be outside the allowed range for the type.
- Casts to or from a pointer to a floating type results in undefined behavior.

Message in Report

A cast shall not be performed between pointer to object and a non-integer arithmetic type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Casts from Pointer to Non-Integer Arithmetic Types

```
int foo(void) {

    short *p;
    float  f;
    long  *l;

    f = (float)   p;              /* Non-compliant */
    p = (short *) f;              /* Non-compliant */

    l = (long *)  p;              /* Compliant */
}
```

In this example, the rule is violated when:

- The pointer `p` is cast to `float`.
- A `float` variable is cast to a pointer to `short`.

The rule is not violated when the pointer `p` is cast to `long*`.

Check Information

Group: Pointer Type Conversions
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 11.4`

Introduced in R2014b

MISRA C:2012 Rule 11.8

A cast shall not remove any const or volatile qualification from the type pointed to by a pointer

Description

Rule Definition

A cast shall not remove any const or volatile qualification from the type pointed to by a pointer.

Rationale

This rule forbids:

- Casts from a pointer to a `const` object to a pointer that does not point to a `const` object.
- Casts from a pointer to a `volatile` object to a pointer that does not point to a `volatile` object.

Such casts violate type qualification. For example, the `const` qualifier indicates the read-only status of an object. If a cast removes the qualifier, the object is no longer read-only.

Polyspace Implementation

Polyspace flags both implicit and explicit conversions that violate this rule.

Message in Report

A cast shall not remove any const or volatile qualification from the type pointed to by a pointer.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Casts That Remove Qualifiers

```
void foo(void) {

    /* Cast on simple type */
    unsigned short           x;
    unsigned short * const   cpi = &x;  /* const pointer */
    unsigned short * const  *pcpi;   /* pointer to const pointer */
    unsigned short **ppi;
    const unsigned short    *pci;    /* pointer to const */
    volatile unsigned short *pvi;    /* pointer to volatile  */
    unsigned short          *pi;

    pi = cpi;                        /* Compliant - no cast required */
    pi  = (unsigned short *)  pci;   /* Non-compliant */
    pi  = (unsigned short *)  pvi;   /* Non-compliant */
    ppi = (unsigned short **)pcpi;   /* Non-compliant */
}
```

In this example:

- The variables `pci` and `pcpi` have the `const` qualifier in their type. The rule is violated when the variables are cast to types that do not have the `const` qualifier.
- The variable `pvi` has a `volatile` qualifier in its type. The rule is violated when the variable is cast to a type that does not have the `volatile` qualifier.

Even though `cpi` has a `const` qualifier in its type, the rule is not violated in the statement `p=cpi;`. The assignment does not cause a type conversion because both `p` and `cpi` have type `unsigned short`.

Check Information

Group: Pointer Type Conversions
Category: Required
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Rule 11.3

Introduced in R2014b

MISRA C:2012 Rule 11.9

The macro NULL shall be the only permitted form of integer null pointer constant

Description

Rule Definition

The macro NULL shall be the only permitted form of integer null pointer constant.

Rationale

The following expressions require the use of a null pointer constant:

- Assignment to a pointer
- The == or != operation, where one operand is a pointer
- The ?: operation, where one of the operands on either side of : is a pointer

Using `NULL` rather than 0 makes it clear that a null pointer constant was intended.

Message in Report

The macro NULL shall be the only permitted form of integer null pointer constant.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Using 0 for Pointer Assignments and Comparisons

```
void main(void) {
```

```
    int *p1 = 0;              /* Non-compliant */
    int *p2 = ( void * ) 0;   /* Compliant     */

#define MY_NULL_1 0
#define MY_NULL_2 ( void * ) 0

    if ( p1 == MY_NULL_1 )    /* Non-compliant */
    { }
    if ( p2 == MY_NULL_2 )    /* Compliant     */
    { }

}
```

In this example, the rule is violated when the constant 0 is used instead of `(void*) 0` for pointer assignments and comparisons.

Check Information

Group: Pointer Type Conversions
Category: Required
AGC Category: Readability
Language: C90, C99

See Also

`MISRA C:2012 Rule 11.4`

Introduced in R2014b

MISRA C:2012 Rule 12.1

The precedence of operators within expressions should be made explicit

Description

Rule Definition

The precedence of operators within expressions should be made explicit.

Rationale

The C language has a large number of operators and their precedence is not intuitive. Inexperienced programmers can easily make mistakes. Remove any ambiguity by using parentheses to explicitly define operator precedence.

The following table list the MISRA C® definition of operator precedence for this rule.

Description	Operator and Operand	Precedence
Primary	identifier, constant, string literal, (expression)	16
Postfix	`[]` `()` (function call) `.` `->` ++(post-increment) --(post-decrement) `()` `{}`(C99: compound literals)	15
Unary	++(post-increment) --(post-decrement) `&` `*` `+` `-` `~` `!` sizeof defined (preprocessor)	14
Cast	`()`	13
Multiplicative	`*` `/` `%`	12
Additive	`+` `-`	11
Bitwise shift	`<<` `>>`	10
Relational	`<>` `<=` `>=`	9
Equality	`==` `!=`	8
Bitwise AND	&	7

Description	Operator and Operand	Precedence
Bitwise XOR	^	6
Bitwise OR	|	5
Logical AND	&&	4
Logical OR	||	3
Conditional	?:	2
Assignment	= *= /= += -= <<= >>= &= ^= |=	1
Comma	,	0

Message in Report

Operand of logical %s is not a primary expression. The precedence of operators within expressions should be made explicit.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Ambiguous Precedence in Multi-Operation Expressions

```
int a, b, c, d, x;

void foo(void) {
  x = sizeof a + b;                    /* Non-compliant - MISRA-12.1 */

  x = a == b ? a : a - b;              /* Non-compliant - MISRA-12.1 */

  x = a <<  b + c ;                    /* Non-compliant - MISRA-12.1 */

  if (a || b && c) { }                 /* Non-compliant - MISRA-12.1 */
```

```
  if ( (a>x) && (b>x) || (c>x) )   { }  /* Non-compliant - MISRA-12.1 */
}
```

This example shows various violations of MISRA rule 12.1. In each violation, if you do not know the order of operations, the code could execute unexpectedly.

Correction — Clarify With Parentheses

To comply with this MISRA rule, add parentheses around individual operations in the expressions. One possible solution is shown here.

```
int a, b, c, d, x;

void foo(void) {
  x = sizeof(a) + b;

  x = ( a == b ) ? a : ( a - b );

  x = a << ( b + c );

  if ( ( a || b ) && c) { }

  if ( ((a>x) && (b>x)) || (c>x) ) { }
}
```

Ambiguous Precedence In Preprocessing Expressions

```
# if defined X && X + Y > Z    /* Non-compliant - MISRA-12.1 */
# endif

# if ! defined X && defined Y  /* Non-compliant - MISRA-12.1 */
# endif
```

In this example, two violations of MISRA rule 12.1 are shown in preprocessing code. In each violation, if you do not know the correct order of operations, the results can be unexpected and cause problems.

Correction — Clarify with Parentheses

To comply with this MISRA rule, add parentheses around individual operations in the expressions. One possible solution is shown here.

```
# if defined (X) && ( (X + Y) > Z )
# endif
```

```
# if ! defined (X) && defined (Y)
# endif
```

Compliant Expressions Without Parentheses

```
int a, b, c, x;
struct {int a; } s, *ps, *pp[2];

void foo(void) {
  ps = &s

  pp[i]-> a;          /* Compliant - no need to write (pp[i])->a */
  *ps++;              /* Compliant - no need to write *( p++ ) */

  x = f ( a + b, c ); /* Compliant - no need to write f ( (a+b),c) */

  x = a, b;           /* Compliant - parsed as ( x = a ), b */

  if (a && b && c ){  /* Compliant - all operators have
                       * the same precedence */
}
```

In this example, the expressions shown have multiple operations. However, these expressions are compliant because operator precedence is already clear.

Check Information

Group: Expressions
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 12.2|MISRA C:2012 Rule 12.3|MISRA C:2012 Rule 12.4

MISRA C:2012 Rule 12.2

The right hand operand of a shift operator shall lie in the range zero to one less than the width in bits of the essential type of the left hand operand

Description

Rule Definition

The right hand operand of a shift operator shall lie in the range zero to one less than the width in bits of the essential type of the left hand operand.

Rationale

Consider the following statement:

```
var = abc << num;
```

If `abc` is a 16-bit integer, then `num` must be in the range 0–15, (nonnegative and less than 16). If `num` is negative or greater than 16, then the shift behavior is undefined.

Polyspace Implementation

In Polyspace, the numbers that are manipulated in preprocessing directives are 64 bits wide. The valid shift range is between 0 and 63. When bitfields are within a complex expression, Polyspace extends this check onto the bitfield field width or the width of the base type.

Message in Report

- Shift amount is bigger than *`size`*.
- Shift amount is negative.
- The right operand of a shift operator shall lie in the range zero to one less than the width in bits of the essential type of the left operand.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Expressions
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 12.1`

MISRA C:2012 Rule 12.3

The comma operator should not be used

Description

Rule Definition

The comma operator should not be used.

Rationale

The comma operator can be detrimental to readability. You can often write the same code in another form.

Message in Report

The comma operator should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Comma Usage in C Code

```
typedef signed int abc, xyz, jkl;

static void func1 ( abc, xyz, jkl );       /* Compliant - case 1 */

int foo(void)
{
```

```
    volatile int rd = 1;                    /* Compliant - case 2*/
    int var=0, foo=0, k=0, n=2, p, t[10];   /* Compliant - case 3*/

    int abc = 0, xyz = abc + 1;             /* Compliant - case 4*/
    int jkl = ( abc + xyz, abc + xyz );     /* Not compliant - case 1*/

    var = 1, foo += var, kkk = 3;           /* Not compliant - case 2*/
    var = (kkk = 1, foo = 2);               /* Not compliant - case 3*/

    for ( var = 0, ptr = &t[ 0 ]; var < num; ++var, ++ptr){}
                                            /* Not compliant - case 4*/

    if ((abc,xyz)<0) { return 1; }          /* Not compliant - case 5*/
}
```

In this example, the code shows various uses of commas in C code.

Noncompliant Cases

Case	Reason for noncompliance
1	When reading the code, it is not immediately obvious what `jkl` is initialized to. For example, you could infer that `jkl` has a value `abc+xyz`, `(abc+xyz)*(abc+xyz)`, `f((abc+xyz),(abc +xyz))`, and so on.
2	When reading the code, it is not immediately obvious whether `foo` has a value 0 or 1 after the statement.
3	When reading the code, it is not immediately obvious what value is assigned to `var`.
4	When reading the code, it is not immediately obvious which values control the `for` loop.
5	When reading the code, it is not immediately obvious whether the `if` statement depends on `abc`, `xyz`, or both.

Compliant Cases

Case	Reason for compliance
1	Using commas to call functions with variables is allowed.
2	Comma operator is not used.

Case	Reason for compliance
3 & 4	When using the comma for initialization, the variables and their values are immediately obvious.

Check Information

Group: Expressions
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 12.1

MISRA C:2012 Rule 12.4

Evaluation of constant expressions should not lead to unsigned integer wrap-around

Description

Rule Definition

Evaluation of constant expressions should not lead to unsigned integer wrap-around.

Rationale

Unsigned integer expressions do not strictly overflow, but instead wraparound. Although there may be good reasons to use modulo arithmetic at run time, intentional use at compile time is less likely.

Message in Report

Evaluation of constant expressions should not lead to unsigned integer wrap-around.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Expressions
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 12.1

MISRA C:2012 Rule 12.5

The `sizeof` operator shall not have an operand which is a function parameter declared as “array of type”

Description

Rule Definition

The `sizeof` operator shall not have an operand which is a function parameter declared as “array of type”.

Rationale

The `sizeof` operator acting on an array normally returns the array size in bytes. For instance, in the following code, `sizeof(arr)` returns the size of `arr` in bytes.

```
int32_t arr[4];
size_t numberOfElements = sizeof (arr) / sizeof(arr[0]);
```

However, when the array is a function parameter, it degenerates to a pointer. The `sizeof` operator acting on the array returns the corresponding pointer size and not the array size.

The use of `sizeof` operator on an array that is a function parameter typically indicates an unintended programming error.

Message in Report

The `sizeof` operator shall not have an operand which is a function parameter declared as “array of type”.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Incorrect Use of `sizeof` Operator

```
int32_t glbA[] = { 1, 2, 3, 4, 5 };
void f (int32_t A[4])
{
         uint32_t numElements = sizeof(A) / sizeof(int32_t);  /* Non-compliant */
        uint32_t numElements_glbA = sizeof(glbA) / sizeof(glbA[0]);  /* Compliant */
}
```

In this example, the variable `numElements` always has the same value of 1, irrespective of the number of members that appear to be in the array (4 in this case), because `A` has type `int32_t *` and not `int32_t[4]`.

The variable `numElements_glbA` has the expected vale of 5 because the `sizeof` operator acts on the global array `glbA`.

Check Information

Group: Expressions
Category: Mandatory
AGC Category: Mandatory
Language: C90, C99

See Also

Introduced in R2017a

MISRA C:2012 Rule 13.1

Initializer lists shall not contain persistent side effects

Description

Rule Definition

Initializer lists shall not contain persistent side effects.

Rationale

C99 permits initializer lists with expressions that can be evaluated only at run-time. However, the order in which elements of the list are evaluated is not defined. If one element of the list modifies the value of a variable which is used in another element, the ambiguity in order of evaluation causes undefined values. Therefore, this rule requires that expressions occurring in an initializer list cannot modify the variables used in them.

Message in Report

Initializer lists shall not contain persistent side effects.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Initializers with Persistent Side Effect

```
volatile int v;
int x;
int y;
```

```
void f(void) {
    int arr[2] = {x+y,x-y};  /* Compliant */
    int arr2[2] = {v,0};      /* Non-compliant */
    int arr3[2] = {x++,y};    /* Non-compliant */
}
```

In this example, the rule is not violated in the first initialization because the initializer does not modify either `x` or `y`. The rule is violated in the other initializations.

- In the second initialization, because `v` is volatile, the initializer can modify `v`.
- In the third initialization, the initializer modifies the variable `x`.

Check Information

Group: Side Effects
Category: Required
AGC Category: Required
Language: C99

See Also

`MISRA C:2012 Rule 13.2`

Introduced in R2014b

MISRA C:2012 Rule 13.2

The value of an expression and its persistent side effects shall be the same under all permitted evaluation orders

Description

Rule Definition

The value of an expression and its persistent side effects shall be the same under all permitted evaluation orders.

Rationale

If an expression results in different values depending on the order of evaluation, its value becomes implementation-defined.

Polyspace Implementation

An expression can have different values under the following conditions:

- The same variable is modified more than once in the expression, or is both read and written.
- The expression allows more than one order of evaluation.

Therefore, this rule forbids expressions where a variable is modified more than once and can cause different results under different orders of evaluation.

Message in Report

The value of 'XX' depends on the order of evaluation. The value of volatile 'XX' depends on the order of evaluation because of multiple accesses.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Variable Modified More Than Once in Expression

```
int a[10], b[10];
#define COPY_ELEMENT(index) (a[(index)]=b[(index)])

void main () {
    int i=0, k=0;

    COPY_ELEMENT (k);         /* Compliant */
    COPY_ELEMENT (i++);       /* Noncompliant  */
}
```

In this example, the rule is violated by the statement `COPY_ELEMENT(i++)` because `i++` occurs twice and the order of evaluation of the two expressions is unspecified.

Variable Modified and Used in Multiple Function Arguments

```
void f (unsigned int param1, unsigned int param2) {}

void main () {
    unsigned int i=0;
    f ( i++, i );                 /* Non-compliant */
}
```

In this example, the rule is violated because it is unspecified whether the operation `i++` occurs before or after the second argument is passed to `f`. The call `f(i++,i)` can translate to either `f(0,0)` or `f(0,1)`.

Check Information

Group: Side Effects
Category: Required

AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Dir 4.9|MISRA C:2012 Rule 13.1|MISRA C:2012 Rule 13.3|MISRA C:2012 Rule 13.4

Introduced in R2014b

MISRA C:2012 Rule 13.3

A full expression containing an increment (++) or decrement (--) operator should have no other potential side effects other than that caused by the increment or decrement operator

Description

Rule Definition

A full expression containing an increment (++) or decrement (--) operator should have no other potential side effects other than that caused by the increment or decrement operator.

Rationale

The rule is violated if the following happens in the same line of code:

- The increment or decrement operator acts on a variable.
- Another read or write operation is performed on the variable.

For example, the line `y=x++` violates this rule. The `++` and `=` operator both act on `x`.

Although the operator precedence rules determine the order of evaluation, placing the `++` and another operator in the same line can reduce the readability of the code.

Message in Report

A full expression containing an increment (++) or decrement (--) operator should have no other potential side effects other than that caused by the increment or decrement operator.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Increment Operator Used in Expression with Other Side Effects

```
int input(void);
int choice(void);
int operation(int, int);

int func() {
    int x = input(), y = input(), res;
    int ch = choice();
    if (choice == -1)
        return(x++);
    if (choice == 0) {
        res = x++ + y++;
        return(res);           /* Non-compliant */
    }
    else if (choice == 1) {
        x++;                   /* Compliant */
        y++;                   /* Compliant */
        return (x+y);
    }
    else {
        res = operation(x++,y);
        return(res);           /* Non-compliant */
    }
}
```

In this example, the rule is violated when the expressions containing the ++ operator have side effects other than that caused by the operator. For example, in the expression `return(x++)`, the other side-effect is the `return` operation.

Check Information

Group: Side Effects
Category: Advisory
AGC Category: Readability
Language: C90, C99

See Also

MISRA C:2012 Rule 13.2

Introduced in R2014b

MISRA C:2012 Rule 13.4

The result of an assignment operator should not be used

Description

Rule Definition

The result of an assignment operator should not be used.

Rationale

The rule is violated if the following happens in the same line of code:

- The assignment operator acts on a variable.
- Another read or operation is performed on the result of the assignment.

For example, the line `a[x]=a[x=y];` violates this rule. The `[]` operator acts on the result of the assignment `x=y`.

Message in Report

The result of an assignment operator should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Result of Assignment Used

```
int x, y, b, c, d;
int a[10];
```

```
unsigned int bool_var, false=0, true=1;

int foo(void) {

    x = y;            /* Compliant - x is not used */

    a[x] = a[x = y];  /* Non-compliant - Value of x=y is used */

    if ( bool_var = false ) {}
                     /* Non-compliant - bool_var=false is used */

    if ( bool_var == false ) {}   /* Compliant */

    if ( ( 0u == 0u ) || ( bool_var = true ) ) {}
    /* Non-compliant - even though (bool_var=true) is not evaluated */

    if ( ( x = f () ) != 0 ) {}
                   /* Non-compliant - value of x=f() is used */

    a[b += c] = a[b];
                   /* Non-compliant - value of b += c is used */

    b = c = d = 0; /* Non-compliant - value of d=0 and c=d=0 are used */

}
```

In this example, the rule is violated when the result of an assignment is used.

Check Information

Group: Side Effects
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 13.2

Introduced in R2014b

MISRA C:2012 Rule 13.5

The right hand operand of a logical && or || operator shall not contain persistent side effects

Description

Rule Definition

The right hand operand of a logical && or || operator shall not contain persistent side effects.

Rationale

The right operand of an `||` operator is not evaluated if the left operand is true. The right operand of an && operator is not evaluated if the left operand is false. In these cases, if the right operand modifies the value of a variable, the modification does not take place. Following the operation, if you expect a modified value of the variable, the modification might not always happen.

Polyspace Implementation

- For this rule, Polyspace considers that all function calls have a persistent side effect.

  If a pure function is flagged, before ignoring this rule violation, make sure that the function has no side effects. For instance, floating-point functions such as `abs()` seem to only return a value and have no other side effect. However, these functions make use of the FPU Register Stack and can have side-effects in certain architectures, for instance, certain Intel® architectures.
- If the right operand is a volatile variable, Polyspace does not flag this as a rule violation.

Message in Report

The right hand operand of a && operator shall not contain side effects. The right hand operand of a || operator shall not contain side effects.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Right Operand of Logical Operator with Persistent Side Effects

```
int check (int arg) {
    static int count;
    if(arg > 0) {
        count++;                    /* Persistent side effect */
        return 1;
    }
    else
        return 0;
}

int getSwitch(void);
int getVal(void);

void main(void) {
    int val = getVal();
    int mySwitch = getSwitch();
    int checkResult;

    if(mySwitch && check(val)) {   /* Non-compliant */
    }

    checkResult = check(val);
    if(checkResult && mySwitch) {  /* Compliant */
    }

    if(check(val) && mySwitch) {   /* Compliant */
    }
}
```

In this example, the rule is violated when the right operand of the && operation contains a function call. The function call has a persistent side effect because the static variable `count` is modified in the function body. Depending on `mySwitch`, this modification might or might not happen.

The rule is not violated when the left operand contains a function call. Alternatively, to avoid the rule violation, assign the result of the function call to a variable. Use this variable in the logical operation in place of the function call.

In this example, the function call has the side effect of modifying a `static` variable. Polyspace flags all function calls when used on the right-hand side of a logical && or || operator, even when the function does not have a side effect. Manually inspect your function body to see if it has side effects. If the function does not have side effects, add a comment and justification in your Polyspace result explaining why you retained your code.

Check Information

Group: Side Effects
Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 13.6

The operand of the sizeof operator shall not contain any expression which has potential side effects

Description

Rule Definition

The operand of the sizeof operator shall not contain any expression which has potential side effects.

Rationale

The argument of a `sizeof` operator is usually not evaluated at run time. If the argument is an expression, you might wrongly expect that the expression is evaluated.

Polyspace Implementation

The rule is not violated if the argument is a `volatile` variable.

Message in Report

The operand of the sizeof operator shall not contain any expression which has potential side effects.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Expressions in `sizeof` Operator

```
#include <stddef.h>
int x;
int y[40];
struct S {
    int a;
    int b;
};
struct S myStruct;

void main() {
    size_t sizeOfType;
    sizeOfType = sizeof(x);         /* Compliant */
    sizeOfType = sizeof(y);         /* Compliant */
    sizeOfType = sizeof(myStruct);  /* Compliant */
    sizeOfType = sizeof(x++);       /* Non-compliant */
}
```

In this example, the rule is violated when the expression `x++` is used as argument of `sizeof` operator.

Check Information

Group: Side Effects
Category: Mandatory
AGC Category: Mandatory
Language: C90, C99

See Also

`MISRA C:2012 Rule 18.8`

Introduced in R2014b

MISRA C:2012 Rule 14.1

A loop counter shall not have essentially floating type

Description

Rule Definition

A loop counter shall not have essentially floating type.

Rationale

When using a floating-point loop counter, accumulation of rounding errors can result in a mismatch between the expected and actual number of iterations. This rounding error can happen when a loop step that is not a power of the floating point radix is rounded to a value that can be represented by a float.

Even if a loop with a floating-point loop counter appears to behave correctly on one implementation, it can give a different number of iteration on another implementation.

Polyspace Implementation

If the `for` index is a variable symbol, Polyspace checks that it is not a float.

Message in Report

A loop counter shall not have essentially floating type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

`for` Loop Counters

```
int main(void){
    unsigned int counter = 0u;
    int result = 0;
    float foo;

    // Float loop counters
    for(float foo = 0.0f; foo < 1.0f; foo +=0.001f){
        /* Non-compliant - counter = 1000 at the end of the loop */
        ++counter;
    }

    float fff = 0.0f;
    for(fff = 0.0f; fff <12.0f; fff += 1.0f){    /* Non-compliant*/
        result++;
    }

    // Integer loop count
    for(unsigned int count = 0u; count < 1000u; ++count){ /* Compliant */
        foo = (float) count * 0.001f;
    }
}
```

In this example, the three `for` loops show three different loop counters. The first and second `for` loops use float variables as loop counters, and therefore are not compliant. The third loop uses the integer `count` as the loop counter. Even though `count` is used as a float inside the loop, the variable remains an integer when acting as the loop index. Therefore, this `for` loop is compliant.

`while` Loop Counters

```
int main(void){
    unsigned int u32a;
    float foo;

    foo = 0.0f;
    while (foo < 1.0f){
        foo += 0.001f;  /* Non-compliant - foo used as a loop counter */
    }
```

```
    foo = read_float32();
    do{
        u32a = read_u32();
    }while( ((float)u32a - foo) > 10.0f );
                        /* Compliant - foo doesn't change in the loop */
                        /*  so cannot be a counter */
    return 1;
}
```

This example shows two `while` loops both of which use `foo` in the `while`-loop conditions.

The first `while` loop uses `foo` in the condition and inside the loop. Because `foo` changes, floating-point rounding errors can cause unexpected behavior.

The second `while` loop does not use `foo` inside the loop, but does use `foo` inside the `while`-condition. So `foo` is not the loop counter. The integer `u32a` is the loop counter because it changes inside the loop and is part of the while condition. Because `u32a` is an integer, the rounding error issue is not a concern, making this `while` loop compliant.

Check Information

Group: Control Statement Expressions
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 14.2`

MISRA C:2012 Rule 14.2

A for loop shall be well-formed

Description

Rule Definition

A for loop shall be well-formed.

Rationale

The `for` statement provides a general-purpose looping facility. Using a restricted form of loop makes code easier to review and to analyze.

Polyspace Implementation

Polyspace checks that:

- The `for` loop index (`V`) is a variable symbol.
- `V` is the last assigned variable in the first expression (if present).
- If the first expression exists, it contains an assignment of `V`.
- If the second expression exists, it is a comparison of `V`.
- If the third expression exists, it is an assignment of `V`.
- There are no direct assignments of the `for` loop index.

Message in Report

- 1st expression should be an assignment. The following kinds of for loops are allowed:
  - all three expressions shall be present;
  - the 2nd and 3rd expressions shall be present with prior initialization of the loop counter;

  - all three expressions shall be empty for a deliberate infinite loop.
- 3rd expression should be an assignment of a loop counter.
- 3rd expression : assigned variable should be the loop counter (*`counter`*).
- 3rd expression should be an assignment of loop counter (*`counter`*) only.
- 2nd expression should contain a comparison with loop counter (*`counter`*).
- Loop counter (*`counter`*) should not be modified in the body of the loop.
- Bad type for loop counter (*`counter`*).

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Altering the Loop Counter Inside the Loop

```
void foo(void){

    for(short index=0; index < 5; index++){  /* Non-compliant */
        index = index + 3;       /* Altering the loop counter */
    }
}
```

In this example, the loop counter `index` changes inside the `for` loop. It is hard to determine when the loop terminates.

Correction — Use Another Variable to Terminate Early

One possible correction is to use an extra flag to terminate the loop early.

In this correction, the second clause of the `for` loop depends on the counter value, `index < 5`, and upon an additional flag, `!flag`. With the additional flag, the for loop definition and counter remain readable, and you can escape the loop early.

```
#define FALSE 0
#define TRUE  1
```

```
void foo(void){

    int flag = FALSE;

    for(short index=0; (index < 5) && !flag; index++){ /* Compliant */
        if((index % 4) == 0){
            flag = TRUE;        /* allows early termination of loop */
        }
    }
}
```

`for` Loops With Empty Clauses

```
void foo(void)
    for(short index = 0; ; index++) {}   /* Non-compliant */

    for(short index = 0; index < 10;) {} /* Non-compliant */

    short index;
    for(; index < 10;) {}     /* Non-compliant */

    for(; index < 10; i++) {} /* Compliant */

    for(;;){}
          /* Compliant - Exception all three clauses can be empty */
}
```

This example shows `for` loops definitions with a variety of missing clauses. To be compliant, initialize the first clause variable before the `for` loop (line 9). However, you cannot have a `for` loop without the second or third clause.

The one exception is a `for` loop with all three clauses empty, so as to allow for infinite loops.

Check Information

Group: Control Statement Expressions
Category: Required
AGC Category: Readability
Language: C90, C99

See Also

MISRA C:2012 Rule 14.1|MISRA C:2012 Rule 14.3|MISRA C:2012 Rule 14.4

MISRA C:2012 Rule 14.3

Controlling expressions shall not be invariant

Description

Rule Definition

Controlling expressions shall not be invariant.

Rationale

If the controlling expression, for example an `if` condition, has a constant value, the non-changing value can point to a programming error.

Polyspace Implementation

Polyspace Bug Finder and Polyspace Code Prover check this coding rule differently. The analyses can produce different results.

Polyspace Bug Finder flags some violations of MISRA C 14.3 through the `Dead code` and `Useless if` checkers.

Polyspace Code Prover does not use gray code to flag MISRA C 14.3 violations. In Code Prover, you can also see a difference in results based on your choice for the option `Verification level (-to)`. See . For more information on analysis options, see the documentation for Polyspace Code Prover or Polyspace Code Prover Server.

Message in Report

- Boolean operations whose results are invariant shall not be permitted.
- Expression is always true.
- Boolean operations whose results are invariant shall not be permitted.
- Expression is always false.

- Controlling expressions shall not be invariant.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Control Statement Expressions
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 2.1|MISRA C:2012 Rule 14.2`

MISRA C:2012 Rule 14.4

The controlling expression of an if statement and the controlling expression of an iteration-statement shall have essentially Boolean type

Description

Rule Definition

The controlling expression of an if statement and the controlling expression of an iteration-statement shall have essentially Boolean type

Rationale

Strong typing requires the controlling expression on an `if` statement or iteration statement to have *essentially Boolean* type.

Polyspace Implementation

Polyspace does not flag integer constants, for example `if(2)`.

If your configuration includes the option `-boolean-types`, the number of warnings can increase or decrease.

Message in Report

The controlling expression of an if statement and the controlling expression of an iteration-statement shall have essentially Boolean type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Controlling Expression in `if`, `while`, and `for`

```
#include <stdbool.h>
#include <stdlib.h>

#define TRUE = 1

typedef _Bool bool_t;
extern bool_t flag;

void foo(void){
    int *p = 1;
    int *q = 0;
    int i = 0;
    while(p){}           /* Non-compliant - p is a pointer */

    while(q != NULL){}   /* Compliant */

    while(TRUE){}        /* Compliant */

    while(flag){}        /* Compliant */

    if(i){}              /* Non-compliant - int32_t is not boolean */

    if(i != 0){}         /* Compliant */

    for(int i=-10; i;i++){}   /* Non-compliant - int32_t is not boolean */

    for(int i=0; i<10;i++){}  /* Compliant */
}
```

This example shows various controlling expressions in `while`, `if`, and `for` statements.

The noncompliant statements (the first `while`, `if`, and `for` examples), use a single non-Boolean variable. If you use a single variable as the controlling statement, it must be essentially Boolean (lines 17 and 19). Boolean expressions are also compliant with MISRA.

Check Information

Group: Control Statement Expressions
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 14.2|MISRA C:2012 Rule 20.8

MISRA C:2012 Rule 15.1

The goto statement should not be used

Description

Rule Definition

The goto statement should not be used.

Rationale

Unrestricted use of `goto` statements makes the program unstructured and difficult to understand.

Message in Report

The `goto` statement should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Use of `goto` Statements

```
void foo(void) {
    int i = 0, result = 0;

label1:
    for ( i; i < 5; i++ ) {
        if (i > 2) goto label2;     /* Non-compliant */
```

```
    }

label2: {
        result++;
        goto label1;                /* Non-compliant */
    }
}
```

In this example, the rule is violated when `goto` statements are used.

Check Information

Group: Control Flow
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 15.2|MISRA C:2012 Rule 15.3|MISRA C:2012 Rule 15.4`

Introduced in R2014b

MISRA C:2012 Rule 15.2

The goto statement shall jump to a label declared later in the same function

Description

Rule Definition

The goto statement shall jump to a label declared later in the same function.

Rationale

Unrestricted use of `goto` statements makes the program unstructured and difficult to understand. You can use a forward `goto` statement together with a backward one to implement iterations. Restricting backward `goto` statements ensures that you use only iteration statements provided by the language such as `for` or `while` to implement iterations. This restriction reduces visual complexity of the code.

Message in Report

The goto statement shall jump to a label declared later in the same function.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Use of Backward `goto` Statements

```
void foo(void) {
    int i = 0, result = 0;
```

```
label1:
    for ( i; i < 5; i++ ) {
        if (i > 2) goto label2;   /* Compliant */
    }

label2: {
        result++;
        goto label1;               /* Non-compliant */
    }
}
```

In this example, the rule is violated when a `goto` statement causes a backward jump to `label1`.

The rule is not violated when a `goto` statement causes a forward jump to `label2`.

Check Information

Group: Control Flow
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 15.1|MISRA C:2012 Rule 15.3|MISRA C:2012 Rule 15.4`

Introduced in R2014b

MISRA C:2012 Rule 15.3

Any label referenced by a goto statement shall be declared in the same block, or in any block enclosing the goto statement

Description

Rule Definition

Any label referenced by a goto statement shall be declared in the same block, or in any block enclosing the goto statement.

Rationale

Unrestricted use of `goto` statements makes the program unstructured and difficult to understand. Restricting use of `goto` statements to jump between blocks or into nested blocks reduces visual code complexity.

Message in Report

Any label referenced by a goto statement shall be declared in the same block, or in any block enclosing the goto statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

`goto` Statements Jump Inside Block

```
void f1(int a) {
    if(a <= 0) {
```

```
        goto L2;        /* Non-compliant - L2 in different block*/
    }

    goto L1;            /* Compliant - L1 in same block*/

    if(a == 0) {
        goto L1;        /* Compliant - L1 in outer block*/
    }

    goto L2;            /* Non-compliant - L2 in inner block*/

    L1: if(a > 0) {
            L2:;
    }
}
```

In this example, `goto` statements cause jumps to different labels. The rule is violated when:

- The label occurs in a block different from the block containing the `goto` statement.

  The block containing the label neither encloses nor is enclosed by the current block.
- The label occurs in a block enclosed by the block containing the `goto` statement.

The rule is not violated when:

- The label occurs in the same block as the block containing the `goto` statement..
- The label occurs in a block that encloses the block containing the `goto` statement..

`goto` Statements in `switch` Block

```
void f2 ( int x, int z ) {
    int y = 0;

    switch(x) {
    case 0:
        if(x == y) {
            goto L1;  /* Non-compliant - switch-clauses are treated as blocks */
        }
        break;
    case 1:
        y = x;
        L1: ++x;
```

```
        break;
    default:
        break;
    }

}
```

In this example, the label for the `goto` statement appears to occur in a block that encloses the block containing the `goto` statement. However, for the purposes of this rule, the software considers that each `case` statement begins a new block. Therefore, the `goto` statement violates the rule.

Check Information

Group: Control Flow
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 15.1|MISRA C:2012 Rule 15.2|MISRA C:2012 Rule 15.4|MISRA C:2012 Rule 16.1`

Introduced in R2014b

MISRA C:2012 Rule 15.4

There should be no more than one break or goto statement used to terminate any iteration statement

Description

Rule Definition

There should be no more than one break or goto statement used to terminate any iteration statement.

Rationale

If you use one `break` or `goto` statement in your loop, you have one secondary exit point from the loop. Restricting number of exits from a loop in this way reduces visual complexity of your code.

Message in Report

There should be no more than one break or goto statement used to terminate any iteration statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

`break` Statements in Inner and Outer Loops

```
volatile int stop;
```

```
int func(int *arr, int size, int sat) {
    int i,j;
    int sum = 0;
    for (i=0; i< size; i++) {   /* Compliant  */
        if(sum >= sat)
            break;
        for (j=0; j< i; j++) {  /* Compliant */
            if(stop)
                break;
            sum += arr[j];
        }
    }
}
```

In this example, the rule is not violated in both the inner and outer loop because both loops have one `break` statement each.

`break` and `goto` Statements in Loop

```
volatile int stop;

void displayStopMessage();

int func(int *arr, int size, int sat) {
    int i;
    int sum = 0;
    for (i=0; i< size; i++) {   /* Non-compliant  */
        if(sum >= sat)
            break;
        if(stop)
            goto L1;
        sum += arr[i];
    }

    L1: displayStopMessage();
}
```

In this example, the rule is violated because the `for` loop has one `break` statement and one `goto` statement.

`goto` Statement in Inner Loop and `break` Statement in Outer Loop

```
volatile int stop;

void displayMessage();

int func(int *arr, int size, int sat) {
    int i,j;
    int sum = 0;
    for (i=0; i< size; i++) {  /* Non-compliant */
        if(sum >= sat)
            break;
        for (j=0; j< i; j++) { /* Compliant */
            if(stop)
                goto L1;
            sum += arr[i];
        }
    }

    L1: displayMessage();
}
```

In this example, the rule is not violated in the inner loop because you can exit the loop only through the one `goto` statement. However, the rule is violated in the outer loop because you can exit the loop through either the `break` statement or the `goto` statement in the inner loop.

Check Information

Group: Control Flow
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 15.1|MISRA C:2012 Rule 15.2|MISRA C:2012 Rule 15.3`

Introduced in R2014b

MISRA C:2012 Rule 15.5

A function should have a single point of exit at the end

Description

Rule Definition

A function should have a single point of exit at the end.

Rationale

This rule requires that a `return` statement must occur as the last statement in the function body. Otherwise, the following issues can occur:

- Code following a `return` statement can be unintentionally omitted.
- If a function that modifies some of its arguments has early `return` statements, when reading the code, it is not immediately clear which modifications actually occur.

Message in Report

A function should have a single point of exit at the end.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

More Than One `return` Statement in Function

```
#define MAX ((unsigned int)2147483647)
#define NULL (void*)0
```

```
typedef unsigned int bool_t;
bool_t false = 0;
bool_t true = 1;

bool_t f1(unsigned short n, char *p) {          /* Non-compliant */
    if(n > MAX) {
        return false;
    }

    if(p == NULL) {
        return false;
    }

    return true;
}
```

In this example, the rule is violated because there are three `return` statements.

Correction — Use Variable to Store Return Value

One possible correction is to store the return value in a variable and return this variable just before the function ends.

```
#define MAX ((unsigned int)2147483647)
#define NULL (void*)0

typedef unsigned int bool_t;
bool_t false = 0;
bool_t true = 1;
bool_t return_value;

bool_t f2 (unsigned short n, char *p) {         /* Compliant */
    return_value = true;
    if(n > MAX) {
        return_value = false;
    }

    if(p == NULL) {
        return_value = false;
    }

    return return_value;
}
```

Check Information

Group: Control Flow
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 17.4

Introduced in R2014b

MISRA C:2012 Rule 15.6

The body of an iteration-statement or a selection-statement shall be a compound statement

Description

Rule Definition

The body of an iteration-statement or a selection-statement shall be a compound-statement.

Rationale

The rule applies to:

- Iteration statements such as `while`, `do ... while` or `for`.
- Selection statements such as `if ... else` or `switch`.

If the block of code associated with an iteration or selection statement is not contained in braces, you can make mistakes about the association. For example:

- You can wrongly associate a line of code with an iteration or selection statement because of its indentation.
- You can accidentally place a semicolon following the iteration or selection statement. Because of the semicolon, the line following the statement is no longer associated with the statement even though you intended otherwise.

Message in Report

- The else keyword shall be followed by either a compound statement, or another if statement.
- An if (expression) construct shall be followed by a compound statement.
- The statement forming the body of a while statement shall be a compound statement.

- The statement forming the body of a do ... while statement shall be a compound statement.
- The statement forming the body of a for statement shall be a compound statement.
- The statement forming the body of a switch statement shall be a compound statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Iteration Block

```
int data_available = 1;
void f1(void) {
    while(data_available)                /* Non-compliant */
        process_data();

    while(data_available) {              /* Compliant */
        process_data();
    }
}
```

In this example, the second `while` block is enclosed in braces and does not violate the rule.

Nested Selection Statements

```
void f1(void) {
    if(flag_1)                           /* Non-compliant */
        if(flag_2)                       /* Non-compliant */
            action_1();
    else                                 /* Non-compliant */
            action_2();
}
```

In this example, the rule is violated because the `if` or `else` blocks are not enclosed in braces. Unless indented as above, it is easy to associate the `else` statement with the inner `if`.

Correction — Place Selection Statement Block in Braces

One possible correction is to enclose each block associated with an `if` or `else` statement in braces.

```
void f1(void) {
    if(flag_1) {                          /* Compliant */
        if(flag_2) {                        /* Compliant */
            action_1();
        }
    }
    else {                                /* Compliant */
        action_2();
    }
}
```

Spurious Semicolon After Iteration Statement

```
void f1(void) {
    while(flag_1);                        /* Non-compliant */
    {
        flag_1 = action_1();
    }
}
```

In this example, the rule is violated even though the `while` statement is followed by a block in braces. The semicolon following the `while` statement causes the block to dissociated from the `while` statement.

The rule helps detect such spurious semicolons.

Check Information

Group: Control Flow
Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 15.7

All if ... else if constructs shall be terminated with an else statement

Description

Rule Definition

All if ... else if constructs shall be terminated with an else statement.

Rationale

Unless there is a terminating `else` statement in an `if...elseif...else` construct, during code review, it is difficult to tell if you considered all possible results for the `if` condition.

Message in Report

All if ... else if constructs shall be terminated with an else statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Missing `else` Block

```
int get_flag_1(void);
int get_flag_2(void);
void action_1(void);
void action_2(void);
```

```
void f1(void) {
    int flag_1 = get_flag_1(), flag_2 = get_flag_2();
    if(flag_1) {
        action_1();
    }
    else if(flag_2) {
        /* Non-compliant */
        action_2();
    }
}
```

In this example, the rule is violated because the `if ... else if` construct does not have a terminating `else` block.

Correction — Add `else` Block

To avoid the rule violation, add a terminating `else` block. The block can be empty.

```
int get_flag_1(void);
int get_flag_2(void);
void action_1(void);
void action_2(void);

void f1(void) {
    int flag_1 = get_flag_1(), flag_2 = get_flag_2();
    if(flag_1) {
        action_1();
    }
    else if(flag_2) {
        /* Non-compliant */
        action_2();
    }
    else {
        /* No statement required */
        /* ; is optional */
    }

}
```

Check Information

Group: Control Flow
Category: Required

AGC Category: Readability
Language: C90, C99

See Also

MISRA C:2012 Rule 16.5

Introduced in R2014b

MISRA C:2012 Rule 16.1

All switch statements shall be well-formed

Description

Rule Definition

All switch statements shall be well-formed

Rationale

The syntax for switch statements in C is not particularly rigorous and can allow complex, unstructured behavior. This rule and other rules impose a simple consistent structure on the `switch` statement.

Polyspace Implementation

Following the MISRA specifications, the coding rules checker also raises a violation of rule 16.1 if a `switch` statement violates one of these rules: 16.2, 16.3, 16.4, 16.5 or 16.6.

Message in Report

All messages in report file begin with "MISRA-C switch statements syntax normative restriction."

- Initializers shall not be used in switch clauses.
- The child statement of a switch shall be a compound statement.
- All switch clauses shall appear at the same level.
- A switch clause shall only contain switch labels and switch clauses, and no other code.
- A switch statement shall only contain switch labels and switch clauses, and no other code.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Switch Statements
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 15.3|MISRA C:2012 Rule 16.2|MISRA C:2012 Rule 16.3|MISRA C:2012 Rule 16.4|MISRA C:2012 Rule 16.5|MISRA C:2012 Rule 16.6`

MISRA C:2012 Rule 16.2

A switch label shall only be used when the most closely-enclosing compound statement is the body of a switch statement

Description

Rule Definition

A switch label shall only be used when the most closely-enclosing compound statement is the body of a switch statement

Rationale

The C Standard permits placing a switch label (for instance, `case` or `default`) before any statement contained in the body of a switch statement. This flexibility can lead to unstructured code. To prevent unstructured code, make sure a switch label appears only at the outermost level of the body of a switch statement.

Message in Report

All messages in report file begin with "MISRA-C switch statements syntax normative restriction."

- Initializers shall not be used in switch clauses.
- The child statement of a switch shall be a compound statement.
- All switch clauses shall appear at the same level.
- A switch clause shall only contain switch labels and switch clauses, and no other code.
- A switch statement shall only contain switch labels and switch clauses, and no other code.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Switch Statements
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 16.1

MISRA C:2012 Rule 16.3

An unconditional break statement shall terminate every switch-clause

Description

Rule Definition

An unconditional break statement shall terminate every switch-clause

Rationale

A *switch-clause* is a case containing at least one statement. Two consecutive labels without an intervening statement is compliant with MISRA.

If you fail to end your switch-clauses with a break statement, then control flow “falls” into the next statement. This next statement can be another switch-clause, or the end of the switch. This behavior is sometimes intentional, but more often it is an error. If you add additional cases later, an unterminated switch-clause can cause problems.

Polyspace Implementation

Polyspace raises a warning for each noncompliant `case` clause.

Message in Report

An unconditional break statement shall terminate every switch-clause.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Switch Statements
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 16.1

MISRA C:2012 Rule 16.4

Every switch statement shall have a default label

Description

Rule Definition

Every switch statement shall have a default label

Rationale

The requirement for a `default` label is defensive programming. Even if your switch covers all possible values, there is no guarantee that the input takes one of these values. Statements following the `default` label take some appropriate action. If the `default` label requires no action, use comments to describe why there are no specific actions.

Message in Report

Every switch statement shall have a default label.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Switch Statement Without `default`

```
short func1(short xyz){

    switch(xyz){      /* Non-compliant - default label is required */
        case 0:
```

```
            ++xyz;
            break;
        case 1:
        case 2:
            break;
    }
    return xyz;
}
```

In this example, the switch statement does not include a `default` label, and is therefore noncompliant.

Correction — Add `default` With Error Flag

One possible correction is to use the `default` label to flag input errors. If your switch-clauses cover all expected input, then the default cases flags any input errors.

```
short func1(short xyz){

    switch(xyz){      /* Compliant */
        case 0:
            ++xyz;
            break;
        case 1:
        case 2:
            break;
        default:
            errorflag = 1;
            break;
    }
    if (errorflag == 1)
        return errorflag;
    else
        return xyz;
}
```

Switch Statement for Enumerated Inputs

```
enum Colors{
    RED, GREEN, BLUE
};

enum Colors func2(enum Colors color){
    enum Colors next;
```

```
    switch(color){      /* Non-compliant - default label is required */
        case RED:
            next = GREEN;
            break;
        case GREEN:
            next = BLUE;
            break;
        case BLUE:
            next = RED;
            break;
    }
    return next;
}
```

In this example, the switch statement does not include a `default` label, and is therefore noncompliant. Even though this switch statement handles all values of the enumeration, there is no guarantee that color takes one of the those values.

Correction — Add `default`

To be compliant, add the `default` label to the end of your switch. You can use this case to flag unexpected inputs.

```
enum Colors{
    RED, GREEN, BLUE, ERROR
};

enum Colors func2(enum Colors color){
    enum Colors next;

    switch(color){      /* Compliant */
        case RED:
            next = GREEN;
            break;
        case GREEN:
            next = BLUE;
            break;
        case BLUE:
            next = RED;
            break;
        default:
            next = ERROR;
            break;
```

```
    }

    return next;
}
```

Check Information

Group: Switch Statements
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 2.1|MISRA C:2012 Rule 16.1

MISRA C:2012 Rule 16.5

A default label shall appear as either the first or the last switch label of a switch statement

Description

Rule Definition

A default label shall appear as either the first or the last switch label of a switch statement.

Rationale

Using this rule, you can easily locate the `default` label within a `switch` statement.

Message in Report

A default label shall appear as either the first or the last switch label of a switch statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Default Case in `switch` Statements

```
void foo(int var){

    switch(var){
        default:   /* Compliant - default is the first label */
```

```
        case 0:
            ++var;
            break;
        case 1:
        case 2:
            break;
    }

    switch(var){
        case 0:
            ++var;
            break;
        default:    /* Non-compliant - default is mixed with the case labels */
        case 1:
        case 2:
            break;
    }

    switch(var){
        case 0:
            ++var;
            break;
        case 1:
        case 2:
        default:     /* Compliant - default is the last label */
            break;
    }

    switch(var){
        case 0:
            ++var;
            break;
        case 1:
        case 2:
            break;
        default:      /* Compliant - default is the last label */
            var = 0;
            break;
    }
}
```

This example shows the same switch statement several times, each with `default` in a different place. As the first, third, and fourth switch statements show, `default` must be

the first or last label. `default` can be part of a compound switch-clause (for instance, the third `switch` example), but it must be the last listed.

Check Information

Group: Switch Statements
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 15.7` | `MISRA C:2012 Rule 16.1`

MISRA C:2012 Rule 16.6

Every switch statement shall have at least two switch-clauses

Description

Rule Definition

Every switch statement shall have at least two switch-clauses.

Rationale

A switch statement with a single path is redundant and can indicate a programming error.

Message in Report

Every switch statement shall have at least two switch-clauses.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Switch Statements
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 16.1`

MISRA C:2012 Rule 16.7

A switch-expression shall not have essentially Boolean type

Description

Rule Definition

A switch-expression shall not have essentially Boolean type

Rationale

The C Standard requires the controlling expression to a `switch` statement to have an integer type. Because C implements Boolean values with integer types, it is possible to have a Boolean expression control a `switch` statement. For controlling flow with Boolean types, an `if-else` construction is more appropriate.

Polyspace Implementation

If your configuration uses the `-boolean-types` option, the number of reported violations can increase.

Message in Report

A switch-expression shall not have essentially Boolean type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Switch Statements

Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 17.1

The features of <stdarg.h> shall not be used

Description

Rule Definition

The features of <stdarg.h> shall not be used..

Rationale

The rule forbids use of `va_list`, `va_arg`, `va_start`, `va_end`, and `va_copy`.

You can use these features in ways where the behavior is not defined in the Standard. For instance:

- You invoke `va_start` in a function but do not invoke the corresponding `va_end` before the function block ends.
- You invoke `va_arg` in different functions on the same variable of type `va_list`.
- `va_arg` has the syntax `type va_arg (va_list ap, type)`.

  You invoke `va_arg` with a `type` that is incompatible with the actual type of the argument retrieved from `ap`.

Message in Report

The features of <stdarg.h> shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Use of va_start, va_list, va_arg, and va_end

```
#include<stdarg.h>
void f2(int n, ...) {
    int i;
    double val;
    va_list vl;                          /* Non-compliant */

    va_start(vl, n);                     /* Non-compliant */

    for(i = 0; i < n; i++)
    {
        val = va_arg(vl, double);          /* Non-compliant */
    }

    va_end(vl);                          /* Non-compliant */
}
```

In this example, the rule is violated because `va_start`, `va_list`, `va_arg` and `va_end` are used.

Undefined Behavior of va_arg

```
#include <stdarg.h>
void h(va_list ap) {                     /* Non-compliant */
    double y;

    y = va_arg(ap, double );               /* Non-compliant */
}

void g(unsigned short n, ...) {
    unsigned int x;
    va_list ap;                          /* Non-compliant */

    va_start(ap, n);                     /* Non-compliant */
    x = va_arg(ap, unsigned int);        /* Non-compliant */

    h(ap);
```

```
    /* Undefined - ap is indeterminate because va_arg used in h () */
    x = va_arg(ap, unsigned int);       /* Non-compliant */

}

void f(void) {
    /* undefined - uint32_t:double type mismatch when g uses va_arg () */
    g(1, 2.0, 3.0);
}
```

In this example, `va_arg` is used on the same variable `ap` of type `va_list` in both functions `g` and `h`. In `g`, the second argument is `unsigned int` and in `h`, the second argument is `double`. This type mismatch causes undefined behavior.

Check Information

Group: Function
Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 17.2

Functions shall not call themselves, either directly or indirectly

Description

Rule Definition

Functions shall not call themselves, either directly or indirectly.

Rationale

Variables local to a function are stored in the call stack. If a function calls itself directly or indirectly several times, the available stack space can be exceeded, causing serious failure. Unless the recursion is tightly controlled, it is difficult to determine the maximum stack space required.

Message in Report

Message in Report: Function XX shall not call itself either directly or indirectly. Function XX is called indirectly by YY.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Direct and Indirect Recursion

```
void foo1( void ) {     /* Non-compliant - Indirect recursion foo1->foo2->foo1... */
    foo2();
    foo1();               /* Non-compliant - Direct recursion */
```

```
}

void foo2( void ) {
    foo1();
}
```

In this example, the rule is violated because of:

- Direct recursion `foo1` → `foo1`.
- Indirect recursion `foo1` → `foo2` → `foo1`.

Check Information

Group: Function
Category: Required
AGC Category: Required
Language: C90, C99

See Also

Polyspace Results

Introduced in R2014b

MISRA C:2012 Rule 17.3

A function shall not be declared implicitly

Description

Rule Definition

A function shall not be declared implicitly.

Rationale

An implicit declaration occurs when you call a function before declaring or defining it. When you declare a function explicitly before calling it, the compiler can match the argument and return types with the parameter types in the declaration. If an implicit declaration occurs, the compiler makes assumptions about the argument and return types. For instance, it assumes a return type of `int`. The assumptions might not agree with what you expect and cause undesired type conversions.

Message in Report

Function 'XX' has no complete visible prototype at call.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Function Not Declared Before Call

```
#include <math.h>
```

```
extern double power3 (double val, int exponent);
int getChoice(void);

double func() {
    double res;
    int ch = getChoice();
    if(ch == 0) {
        res = power(2.0, 10);    /* Non-compliant */
    }
    else if( ch==1) {
        res = power2(2.0, 10);   /* Non-compliant */
    }
    else {
        res = power3(2.0, 10);   /* Compliant */
        return res;
    }
}

double power2 (double val, int exponent) {
    return (pow(val, exponent));
}
```

In this example, the rule is violated when a function that is not declared is called in the code. Even if a function definition exists later in the code, the rule violation occurs.

The rule is not violated when the function is declared before it is called in the code. If the function definition exists in another file and is available only during the link phase, you can declare the function in one of the following ways:

- Declare the function with the `extern` keyword in the current file.
- Declare the function in a header file and include the header file in the current file.

Check Information

Group: Function
Category: Mandatory
AGC Category: Mandatory
Language: C90

See Also

`MISRA C:2012 Rule 8.2|MISRA C:2012 Rule 8.4`

Introduced in R2014b

MISRA C:2012 Rule 17.4

All exit paths from a function with non-void return type shall have an explicit return statement with an expression

Description

Rule Definition

All exit paths from a function with non-void return type shall have an explicit return statement with an expression.

Rationale

If a non-`void` function does not explicitly return a value but the calling function uses the return value, the behavior is undefined. To prevent this behavior:

1. You must provide `return` statements with an explicit expression.
2. You must ensure that during run time, at least one `return` statement executes.

Message in Report

Missing return value for non-void function 'XX'.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Missing Return Statement Along Certain Execution Paths

```
int absolute(int v) {
    if(v < 0) {
```

```
        return v;
    }
}
```

In this example, the rule is violated because a `return` statement does not exist on all execution paths. If `v >= 0`, then the control returns to the calling function without an explicit return value.

Return Statement Without Explicit Expression

```
#define SIZE 10
int table[SIZE];

unsigned short lookup(unsigned short v) {
    if((v < 0) || (v > SIZE)) {
        return;
    }
    return table[v];
}
```

In this example, the rule is violated because the `return` statement in the `if` block does not have an explicit expression.

Check Information

Group: Function
Category: Mandatory
AGC Category: Mandatory
Language: C90, C99

See Also

`MISRA C:2012 Rule 15.5`

Introduced in R2014b

MISRA C:2012 Rule 17.5

The function argument corresponding to a parameter declared to have an array type shall have an appropriate number of elements

Description

Rule Definition

The function argument corresponding to a parameter declared to have an array type shall have an appropriate number of elements.

Rationale

If you use an array declarator for a function parameter instead of a pointer, the function interface is clearer because you can state the minimum expected array size. If you do not state a size, the expectation is that the function can handle an array of any size. In such cases, the size value is typically another parameter of the function, or the array is terminated with a sentinel value.

However, it is legal in C to specify an array size but pass an array of smaller size. This rule prevents you from passing an array of size smaller than the size you declared.

Message in Report

The function argument corresponding to a parameter declared to have an array type shall have an appropriate number of elements.

The argument type has *`actual_size`* elements whereas the parameter type expects *`expected_size`* elements.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Incorrect Array Size Passed to Function

```
void func(int arr[4]);

int main() {
    int arrSmall[3] = {1,2,3};
    int arr[4] = {1,2,3,4};
    int arrLarge[5] ={1,2,3,4,5};

    func(arrSmall);      /* Non-compliant */
    func(arr);           /* Compliant */
    func(arrLarge);      /* Compliant */

    return 0;
}
```

In this example, the rule is violated when `arrSmall`, which has size 3, is passed to `func`, which expects at least 4 elements.

Check Information

Group: Functions
Category: Advisory
AGC Category: Readability
Language: C90. C99

See Also

Introduced in R2015b

MISRA C:2012 Rule 17.6

The declaration of an array parameter shall not contain the static keyword between the [ ]

Description

Rule Definition

The declaration of an array parameter shall not contain the static keyword between the [ ].

Rationale

If you use the `static` keyword within `[]` for an array parameter of a function, you can inform a C99 compiler that the array contains a minimum number of elements. The compiler can use this information to generate efficient code for certain processors. However, in your function call, if you provide less than the specified minimum number, the behavior is not defined.

Message in Report

The declaration of an array parameter shall not contain the static keyword between the [ ].

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Use of `static` Keyword Within `[]` in Array Parameter

```
extern int arr1[20];
extern int arr2[10];
```

```
/* Non-compliant: static keyword used in array declarator */
unsigned int total (unsigned int n, unsigned int arr[static 20]) {
    unsigned int i;
    unsigned int sum = 0;

    for (i=0U; i < n; i++) {
        sum+= arr[i];
    }

    return sum;
}

void func (void) {
    int res, res2;
    res = total (10U, arr1);  /* Non-compliant - behavior not defined */
    res2 = total (20U, arr2); /* Non-compliant, even if behavior is defined */
}
```

In this example, the rule is violated when the `static` keyword is used within `[]` in the array parameter of function `total`. Even if you call `total` with array arguments where the behavior is well-defined, the rule violation occurs.

Check Information

Group: Function
Category: Mandatory
AGC Category: Mandatory
Language: C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 17.7

The value returned by a function having non-void return type shall be used

Description

Rule Definition

The value returned by a function having non-void return type shall be used.

Rationale

You can unintentionally call a function with a non-`void` return type but not use the return value. Because the compiler allows the call, you might not catch the omission. This rule forbids calls to a non-`void` function where the return value is not used. If you do not intend to use the return value of a function, explicitly cast the return value to `void`.

Message in Report

The value returned by a function having non-void return type shall be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Used and Unused Return Values

```
unsigned int cutOff(unsigned int val) {
    if (val > 10 && val < 100) {
        return val;
    }
```

```
    else {
        return 0;
    }
}

unsigned int getVal(void);

void func2(void) {
    unsigned int val = getVal(), res;
    cutOff(val);           /* Non-compliant */
    res = cutOff(val);     /* Compliant */
    (void)cutOff(val);     /* Compliant */
}
```

In this example, the rule is violated when the return value of `cutOff` is not used subsequently.

The rule is not violated when the return value is:

- Assigned to another variable.
- Explicitly cast to `void`.

Check Information

Group: Function
Category: Required
AGC Category: Readability
Language: C90, C99

See Also

`MISRA C:2012 Rule 2.2`

Introduced in R2014b

MISRA C:2012 Rule 17.8

A function parameter should not be modified

Description

Rule Definition

A function parameter should not be modified.

Rationale

When you modify a parameter, the function argument corresponding to the parameter is not modified. However, you or another programmer unfamiliar with C can expect by mistake that the argument is also modified when you modify the parameter.

Message in Report

A function parameter should not be modified.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Function Parameter Modified

```
int input(void);

void func(int param1, int* param2) {

    param1 = input();   /* Non-compliant */
```

```
    *param2 = input();  /* Compliant */
}
```

In this example, the rule is violated when the parameter `param1` is modified.

The rule is not violated when the parameter is a pointer `param2` and `*param2` is modified.

Check Information

Group: Functions
Category: Advisory
AGC Category: Readability
Language: C90, C99

See Also

Introduced in R2015b

MISRA C:2012 Rule 18.1

A pointer resulting from arithmetic on a pointer operand shall address an element of the same array as that pointer operand

Description

Rule Definition

A pointer resulting from arithmetic on a pointer operand shall address an element of the same array as that pointer operand.

Rationale

Using an invalid array subscript can lead to erroneous behavior of the program. Run-time derived array subscripts are especially troublesome because they cannot be easily checked by manual review or static analysis.

The C Standard defines the creation of a pointer to one beyond the end of the array. The rule permits the C Standard. Dereferencing a pointer to one beyond the end of an array causes undefined behavior and is noncompliant.

Polyspace Implementation

Polyspace flags this rule during the analysis as:

- Bug Finder — `Array access out-of-bounds` and `Pointer access out-of-bounds`
- Code Prover — and

Bug Finder and Code Prover check this rule differently and can show different results for this rule. In Code Prover, you can also see a difference in results based on your choice for the option `Verification level (-to)`. See . For more information on analysis options, see the documentation for Polyspace Code Prover or Polyspace Code Prover Server.

Message in Report

A pointer resulting from arithmetic on a pointer operand shall address an element of the same array as that pointer operand.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Pointers and Arrays
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Dir 4.1|MISRA C:2012 Rule 18.4`

MISRA C:2012 Rule 18.2

Subtraction between pointers shall only be applied to pointers that address elements of the same array

Description

Rule Definition

Subtraction between pointers shall only be applied to pointers that address elements of the same array.

Rationale

This rule applies to expressions of the form `pointer_expression1 - pointer_expression2`. The behavior is undefined if `pointer_expression1` and `pointer_expression2`:

- Do not point to elements of the same array,
- Or do not point to the element one beyond the end of the array.

Message in Report

Subtraction between pointers shall only be applied to pointers that address elements of the same array.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Subtracting Pointers

```
#include <stddef.h>

void f1 (int32_t *ptr)
{
    int32_t a1[10];
    int32_t a2[10];
    int32_t *p1 = &a1[ 1];
    int32_t *p2 = &a2[10];
    ptrdiff_t diff1, diff2, diff3;

    diff1 =  p1 - a1;   // Compliant
    diff2 =  p2 - a2;   // Compliant
    diff3 =  p1 - p2;   // Non-compliant
}
```

In this example, the three subtraction expressions show the difference between compliant and noncompliant pointer subtractions. The `diff1` and `diff2` subtractions are compliant because the pointers point to the same array. The `diff3` subtraction is not compliant because `p1` and `p2` point to different arrays.

Check Information

Group: Pointers and Arrays
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Dir 4.1|MISRA C:2012 Rule 18.4`

MISRA C:2012 Rule 18.3

The relational operators >, >=, < and <= shall not be applied to objects of pointer type except where they point into the same object

Description

Rule Definition

The relational operators >, >=, <, and <= shall not be applied to objects of pointer type except where they point into the same object.

Rationale

If two pointers do not point to the same object, comparisons between the pointers produces undefined behavior.

You can address the element beyond the end of an array, but you cannot access this element.

Message in Report

The relational operators >, >=, < and <= shall not be applied to objects of pointer type except where they point into the same object.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Pointer and Array Comparisons

```
void f1(void){
    int arr1[10];
    int arr2[10];
    int *ptr1 = arr1;

    if(ptr1 < arr2){}    /* Non-compliant */
    if(ptr1 < arr1){}    /* Compliant */
}
```

In this example, `ptr1` is a pointer to `arr1`. To be compliant with rule 18.3, you can compare only `ptr1` with `arr1`. Therefore, the comparison between `ptr1` and `arr2` is noncompliant.

Structure Comparisons

```
struct limits{
  int lower_bound;
  int upper_bound;
};

void func2(void){
    struct limits lim_1 = { 2, 5 };
    struct limits lim_2 = { 10, 5 };

    if(&lim_1.lower_bound <= &lim_2.upper_bound){}  /* Non-compliant *
    if(&lim_1.lower_bound <= &lim_1.upper_bound){}  /* Compliant */
}
```

This example defines two `limits` structures, `lim1` and `lim2`, and compares the elements. To be compliant with rule 18.3, you can compare only the structure elements within a structure. The first comparison compares the `lower_bound` of `lim1` and the `upper_bound` of `lim2`. This comparison is noncompliant because the `lim_1.lower_bound` and `lim_2.upper_bound` are elements of two different structures.

Check Information

Group: Pointers and Arrays
Category: Required
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Dir 4.1

MISRA C:2012 Rule 18.4

The +, -, += and -= operators should not be applied to an expression of pointer type

Description

Rule Definition

The +, -, += and -= operators should not be applied to an expression of pointer type.

Rationale

The preferred form of pointer arithmetic is using the array subscript syntax `ptr[expr]`. This syntax is clear and less prone to error than pointer manipulation. With pointer manipulation, any explicitly calculated pointer value has the potential to access unintended or invalid memory addresses. Array indexing can also access unintended or invalid memory, but it is easier to review.

To a new C programmer, the expression `ptr+1` can be mistakenly interpreted as one plus the address of `ptr`. However, the new memory address depends on the size, in bytes, of the pointer's target. This confusion can lead to unexpected behavior.

When used with caution, pointer manipulation using ++ can be more natural (for instance, sequentially accessing locations during a memory test).

Polyspace Implementation

Polyspace flags operations on pointers, for example, `Pointer + Integer`, `Integer + Pointer`, `Pointer - Integer`.

Message in Report

The +, -, += and -= operators should not be applied to an expression of pointer type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Pointers and Array Expressions

```
void fun1(void){
    unsigned char arr[10];
    unsigned char *ptr;
    unsigned char index = 0U;

    index = index + 1U;   /* Compliant - rule only applies to pointers */

    arr[index] = 0U;      /* Compliant */
    ptr = &arr[5];        /* Compliant */
    ptr = arr;
    ptr++;                /* Compliant - increment operator not + */
    *(ptr + 5) = 0U;      /* Non-compliant */
    ptr[5] = 0U;          /* Compliant */
}
```

This example shows various operations with pointers and arrays. The only operation in this example that is noncompliant is using the + operator directly with a pointer (line 12).

Adding Array Elements Inside a `for` Loop

```
void fun2(void){
    unsigned char array_2_2[2][2] = {{1U, 2U}, {4U, 5U}};
    unsigned char i = 0U;
    unsigned char j = 0U;
    unsigned char sum = 0U;

    for(i = 0u; i < 2U; i++){
        unsigned char *row = array_2_2[ i ];

        for(j = 0u; j < 2U; j++){
            sum += row[ j ];                  /* Compliant */
        }
```

```
    }
}
```

In this example, the second `for` loop uses the array pointer `row` in an arithmetic expression. However, this usage is compliant because it uses the array index form.

Pointers and Array Expressions

```
void fun3(unsigned char *ptr1, unsigned char ptr2[ ]){
    ptr1++;               /* Compliant */
    ptr1 = ptr1 - 5;      /* Non-compliant */
    ptr1 -= 5;            /* Non-compliant */
    ptr1[2] = 0U;         /* Compliant */

    ptr2++;               /* Compliant */
    ptr2 = ptr2 + 3;      /* Non-compliant */
    ptr2 += 3;            /* Non-compliant */
    ptr2[3] = 0U;         /* Compliant */
}
```

This example shows the offending operators used on pointers and arrays. Notice that the same types of expressions are compliant and noncompliant for both pointers and arrays.

If `ptr1` does not point to an array with at least six elements, and `ptr2` does not point to an array with at least 4 elements, this example violates rule 18.1.

Check Information

Group: Pointers and Arrays
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 18.1|MISRA C:2012 Rule 18.2`

MISRA C:2012 Rule 18.5

Declarations should contain no more than two levels of pointer nesting

Description

Rule Definition

Declarations should contain no more than two levels of pointer nesting.

Rationale

The use of more than two levels of pointer nesting can seriously impair the ability to understand the behavior of the code. Avoid this usage.

Message in Report

Declarations should contain no more than two levels of pointer nesting.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Pointer Nesting

```
typedef char *INTPTR;

void function(char ** arrPar[ ])    /* Non-compliant - 3 levels */
{
    char   **  obj2;            /* Compliant */
    char   *** obj3;            /* Non-compliant */
```

```
    INTPTR *   obj4;            /* Compliant */
    INTPTR * const * const obj5;    /* Non-compliant */
    char   ** arr[10];            /* Compliant */
    char   ** (*parr)[10];        /* Compliant */
    char   *  (**pparr)[10];        /* Compliant */
}

struct s{
    char *   s1;                /* Compliant */
    char **  s2;                /* Compliant */
    char *** s3;                /* Non-compliant */
};

struct s *   ps1;            /* Compliant */
struct s **  ps2;            /* Compliant */
struct s *** ps3;            /* Non-compliant */

char **  (  *pfunc1)(void);        /* Compliant */
char **  ( **pfunc2)(void);        /* Compliant */
char **  (***pfunc3)(void);        /* Non-compliant */
char *** ( **pfunc4)(void);        /* Non-compliant */
```

This example shows various pointer declarations and nesting levels. Any pointer with more than two levels of nesting is considered noncompliant.

Check Information

Group: Pointers and Arrays
Category: Advisory
AGC Category: Readability
Language: C90, C99

See Also

MISRA C:2012 Rule 18.6

The address of an object with automatic storage shall not be copied to another object that persists after the first object has ceased to exist

Description

Rule Definition

The address of an object with automatic storage shall not be copied to another object that persists after the first object has ceased to exist.

Rationale

The address of an object becomes indeterminate when the lifetime of that object expires. Any use of an indeterminate address results in undefined behavior.

Polyspace Implementation

Polyspace flags a violation when assigning an address to a global variable, returning a local variable address, or returning a parameter address.

Message in Report

The address of an object with automatic storage shall not be copied to another object that persists after the first object has ceased to exist.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Address of Local Variables

```
char *func(void){
    char local_auto;
    return &local_auto  /* Non-compliant
                         * &local_auto is indeterminate */
}
```

In this example, because `local_auto` is a local variable, after the function returns, the address of `local_auto` is indeterminate.

Copying Pointer Addresses to Local Variables

```
char *sp;

void f(unsigned short u){
    g(&u);
}

void g(unsigned short *p){
    sp = p;  /* Non-compliant
              * the parameter u from f is copied to static sp */
}

void h(void){
    static unsigned short *q;

    unsigned short x =0u;
    q = &x;  /* Non-compliant -
              * &x stored in object with greater lifetime */
}
```

In this example, the function g stores a copy of its pointer parameter p. If p always points to an object with static storage duration, then the code is compliant with this rule. However, in this example, p points to an object with automatic storage duration. In such a case, copying the parameter p is noncompliant.

Check Information

Group: Pointers and Arrays
Category: Required
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Rule 18.7

Flexible array members shall not be declared

Description

Rule Definition

Flexible array members shall not be declared.

Rationale

Flexible array members are usually used with dynamic memory allocation. Dynamic memory allocation is banned by Directive 4.12 and Rule 21.3 on page 2-241.

Message in Report

Flexible array members shall not be declared.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Pointers and Arrays
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 21.3`

MISRA C:2012 Rule 18.8

Variable-length array types shall not be used

Description

Rule Definition

Variable-length array types shall not be used.

Rationale

When the size of an array declared in a block or function prototype is not an integer constant expression, you specify variable array types. Variable array types are typically implemented as a variable size object stored on the stack. Using variable type arrays can make it impossible to determine statistically the amount of memory for the stack requires.

If the size of a variable-length array is negative or zero, the behavior is undefined.

If a variable-length array must be compatible with another array type, then the size of the array types must be identical and positive integers. If your array does not meet these requirements, the behavior is undefined.

If you use a variable-length array type in a `sizeof`, it is uncertain if the array size is evaluated or not.

Message in Report

Variable-length array types shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Pointers and Arrays
Category: Required
AGC Category: Required
Language: C99

See Also

MISRA C:2012 Rule 13.6

MISRA C:2012 Rule 19.1

An object shall not be assigned or copied to an overlapping object

Description

Rule Definition

An object shall not be assigned or copied to an overlapping object.

Rationale

When you assign an object to another object with overlapping memory, the behavior is undefined. The exceptions are:

- You assign an object to another object with exactly overlapping memory and compatible type.
- You copy one object to another using `memmove`.

Message in Report

- An object shall not be assigned or copied to an overlapping object.
- Destination and source of XX overlap, the behavior is undefined.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Assignment of Union Members

```
void func (void) {
    union {
```

```
        short i;
        int j;
    } a = {0}, b = {1};

    a.j = a.i;   /* Non-compliant */
    a = b;       /* Compliant */
}
```

In this example, the rule is violated when `a.i` is assigned to `a.j` because the two variables have overlapping regions of memory.

Assignment of Array Segments

```
#include <string.h>

int arr[10];

void func(void) {
    memcpy (&arr[5], &arr[4], 2u * sizeof(arr[0]));    /* Non-compliant */
    memcpy (&arr[5], &arr[4], sizeof(arr[0]));         /* Compliant */
    memcpy (&arr[1], &arr[4], 2u * sizeof(arr[0]));    /* Compliant */
}
```

In this example, memory equal to twice `sizeof(arr[0])` is the memory space taken up by two array elements. If that memory space begins from `&a[4]` and `&a[5]`, the two memory regions overlap. The rule is violated when the `memcpy` function is used to copy the contents of these two overlapping memory regions.

Check Information

Group: Overlapping Storage
Category: Mandatory
AGC Category: Mandatory
Language: C90, C99

See Also

`MISRA C:2012 Rule 19.2`

Introduced in R2014b

MISRA C:2012 Rule 19.2

The union keyword should not be used

Description

Rule Definition

The union keyword should not be used.

Rationale

If you write to a union member and read the same union member, the behavior is well-defined. But if you read a different member, the behavior depends on the relative sizes of the members. For instance:

- If you read a union member with wider memory size, the value you read is unspecified.
- Otherwise, the value is implementation-dependant.

Message in Report

The union keyword should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Possible Problems with `union` Keyword

```
unsigned int zext(unsigned int s)
{
```

```
    union                 /* Non-compliant */
    {
        unsigned int ul;
        unsigned short us;
    } tmp;

    tmp.us = s;
    return tmp.ul;        /* Unspecified value */
}
```

In this example, the 16-bit `short` field `tmp.us` is written but the wider 32-bit `int` field `tmp.ul` is read. Using the `union` keyword can cause such unspecified behavior. Therefore, the rule forbids using the `union` keyword.

Check Information

Group: Overlapping Storage
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 19.1`

Introduced in R2014b

MISRA C:2012 Rule 2.1

A project shall not contain unreachable code

Description

Rule Definition

A project shall not contain unreachable code.

Rationale

Unless a program exhibits any undefined behavior, unreachable code cannot execute. The unreachable code cannot affect the program output. The presence of unreachable code can indicate an error in the program logic. Unreachable code that the compiler does not remove wastes resources, for example:

- It occupies space in the target machine memory.
- Its presence can cause a compiler to select longer, slower jump instructions when transferring control around the unreachable code.
- Within a loop, it can prevent the entire loop from residing in an instruction cache.

Polyspace Implementation

Polyspace Bug Finder and Polyspace Code Prover check this coding rule differently. The analyses can produce different results.

The Code Prover run-time check for unreachable code shows more cases than the MISRA checker for rule 2.1. See also . The run-time check performs a more exhaustive analysis. In the process, the check can show some instances that are not strictly unreachable code but unreachable only in the context of the analysis. For instance, in the following code, the run-time check shows a potential division by zero in the first line and then removes the zero value of `flag` for the rest of the analysis. Therefore, it considers the `if` block unreachable.

```
val=1.0/flag;
if(!flag) {}
```

The MISRA checker is designed to prevent these kinds of results.

Message in Report

A project shall not contain unreachable code.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Code Following `return` Statement

```
enum light { red, amber, red_amber, green };

enum light next_light ( enum light color )
{
    enum light res;

    switch ( color )
    {
    case red:
        res = red_amber;
        break;
    case red_amber:
        res = green;
        break;
    case green:
        res = amber;
        break;
    case amber:
        res = red;
        break;
    default:
    {
```

```
        error_handler ();
        break;
    }
    }

    res = color;
    return res;
    res = color;     /* Non-compliant */
}
```

In this example, the rule is violated because there is an unreachable operation following the `return` statement.

Check Information

Group: Unused Code
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 14.3` | `MISRA C:2012 Rule 16.4`

Introduced in R2014b

MISRA C:2012 Rule 2.2

There shall be no dead code

Description

Rule Definition

There shall be no dead code.

Rationale

If an operation is reachable but removing the operation does not affect program behavior, the operation constitutes dead code.

The presence of dead code can indicate an error in the program logic. Because a compiler can remove dead code, its presence can cause confusion for code reviewers.

Operations involving language extensions such as `__asm ( "NOP" );` are not considered dead code.

Polyspace Implementation

Polyspace Bug Finder detects useless write operations during analysis.

Polyspace Code Prover does not detect useless write operations. For instance, if you assign a value to a local variable but do not read it later, Polyspace Code Prover does not detect this useless assignment. Use Polyspace Bug Finder to detect such useless write operations. For more information, see MISRA C:2012 in Polyspace Bug Finder on page 2-172.

In Code Prover, you can also see a difference in results based on your choice for the option `Verification level (-to)`. See . For more information on analysis options, see the documentation for Polyspace Code Prover or Polyspace Code Prover Server.

Message in Report

There shall be no dead code.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Redundant Operations

```
extern volatile unsigned int v;
extern char *p;

void f ( void ) {
    unsigned int x;


    ( void ) v;      /* Compliant - Exception*/
    ( int ) v;       /* Non-compliant  */
    v >> 3;          /* Non-compliant  */

    x = 3;           /* Non-compliant - Detected in Bug Finder only */

    *p++;            /* Non-compliant  */
    ( *p )++;        /* Compliant  */
}
```

In this example, the rule is violated when an operation is performed on a variable, but the result of that operation is not used. For instance,

- The operations `(int)` and `>>` on the variable `v` are redundant because the results are not used.
- The operation `=` is redundant because the local variable `x` is not read after the operation.
- The operation `*` on `p++` is redundant because the result is not used.

The rule is not violated when:

- A variable is cast to `void`. The cast indicates that you are intentionally not using the value.
- The result of an operation is used. For instance, the operation * on `p` is not redundant, because *`p` is incremented.

Redundant Function Call

```
void g ( void ) {
               /* Compliant  */
}

void h ( void) {
     g( );     /* Non-compliant */
}
```

In this example, `g` is an empty function. Though the function itself does not violate the rule, a call to the function violates the rule.

Check Information

Group: Unused Code
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 17.7`

Introduced in R2014b

MISRA C:2012 Rule 2.3

A project should not contain unused type declarations

Description

Rule Definition

A project should not contain unused type declarations.

Rationale

If a type is declared but not used, a reviewer does not know if the type is redundant or if it is unused by mistake.

Message in Report

A project should not contain unused type declarations: type XX is not used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Unused Local Type

```
signed short unusedType (void){

    typedef signed short myType;   /* Non-compliant */
    return 67;

}
```

```
signed short usedType (void){

    typedef signed short myType;  /* Compliant */
    myType tempVar = 67;
    return tempVar;

}
```

In this example, in function `unusedType`, the `typedef` statement defines a new local type `myType`. However, this type is never used in the function. Therefore, the rule is violated.

The rule is not violated in the function `usedType` because the new type `myType` is used.

Check Information

Group: Unused Code
Category: Advisory
AGC Category: Readability
Language: C90, C99

See Also

`MISRA C:2012 Rule 2.4`

Introduced in R2014b

MISRA C:2012 Rule 2.4

A project should not contain unused tag declarations

Description

Rule Definition

A project should not contain unused tag declarations.

Rationale

If a tag is declared but not used, a reviewer does not know if the tag is redundant or if it is unused by mistake.

Message in Report

A project should not contain unused tag declarations: tag *`tag_name`* is not used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Tag Defined in Function but Not Used

```
void unusedTag ( void )
{
    enum state1 { S_init, S_run, S_sleep };    /* Non-compliant  */
}

void usedTag ( void )
```

```
{
    enum state2 { S_init, S_run, S_sleep };    /* Compliant  */
    enum state2 my_State = S_init;
}
```

In this example, in the function `unusedTag`, the tag `state1` is defined but not used. Therefore, the rule is violated.

Tag Used in `typedef` Only

```
typedef struct record_t        /* Non-compliant  */
{
    unsigned short key;
    unsigned short val;
} record1_t;


typedef struct               /* Compliant */
{
    unsigned short key;
    unsigned short val;
} record2_t;

record1_t myRecord1_t;
record2_t myRecord2_t;
```

In this example, the tag `record_t` appears only in the `typedef` of `record1_t`. In the rest of the translation unit, the type `record1_t` is used. Therefore, the rule is violated.

Check Information

Group: Unused Code
Category: Advisory
AGC Category: Readability
Language: C90, C99

See Also

`MISRA C:2012 Rule 2.3`

Introduced in R2014b

MISRA C:2012 Rule 2.5

A project should not contain unused macro declarations

Description

Rule Definition

A project should not contain unused macro declarations.

Rationale

If a macro is declared but not used, a reviewer does not know if the macro is redundant or if it is unused by mistake.

Message in Report

A project should not contain unused macro declarations: macro *`macro_name`* is not used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Unused Macro Definition

```
void use_macro (void)
{
    #define SIZE 4
    #define DATA 3

    use_int16(SIZE);
}
```

In this example, the macro `DATA` is never used in the `use_macro` function.

Check Information

Group: Unused Code
Category: Advisory
AGC Category: Readability
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 2.6

A function should not contain unused label declarations

Description

Rule Definition

A function should not contain unused label declarations.

Rationale

If you declare a label but do not use it, it is not clear to a reviewer of your code if the label is redundant or unused by mistake.

Message in Report

A function should not contain unused label declarations.

Label *`label_name`* is not used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Unused Label Declarations

```
void use_var(signed short);

void unused_label ( void )
{
```

```
    signed short x = 6;

label1:                          /* Non-compliant - label1 not used */
    use_var ( x );
}

void used_label ( void )
{
    signed short x = 6;

    for (int i=0; i < 5; i++) {
        if ( i==2 ) goto label1;
    }

label1:                         /* Compliant - label1 used */
    use_var ( x );
}
```

In this example, the rule is violated when the label `label1` in function `unused_label` is not used.

Check Information

Group: Unused code
Category: Advisory
AGC Category: Readability
Language: C90, C99

See Also

Introduced in R2015b

MISRA C:2012 Rule 2.7

There should be no unused parameters in functions

Description

Rule Definition

There should be no unused parameters in functions.

Rationale

If a parameter is unused, it is possible that the implementation of the function does not match its specifications. This rule can highlight such mismatches.

Message in Report

There should be no unused parameters in functions.

Parameter *`parameter_name`* is not used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Unused Function Parameters

```
double func(int param1, int* param2) {
    return (param1/2.0);
}
```

In this example, the rule is violated because the parameter `param2` is not used.

Check Information

Group: Unused code
Category: Advisory
AGC Category: Readability
Language: C90, C99

See Also

Introduced in R2015b

MISRA C:2012 Rule 20.1

#include directives should only be preceded by preprocessor directives or comments

Description

Rule Definition

#include directives should only be preceded by preprocessor directives or comments.

Rationale

For better code readability, group all `#include` directives in a file at the top of the file. Undefined behavior can occur if you use `#include` to include a standard header file within a declaration or definition, or if you use part of the Standard Library before including the related standard header files.

Polyspace Implementation

Polyspace flags text that precedes a `#include` directive. Polyspace ignores preprocessor directives, comments, spaces, or "new lines".

Message in Report

#include directives should only be preceded by preprocessor directives or comments.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Preprocessing Directives

Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 20.10

The # and ## preprocessor operators should not be used

Description

Rule Definition

The # and ## preprocessor operators should not be used.

Rationale

The order of evaluation associated with multiple #, multiple ##, or a mix of # and ## preprocessor operators is unspecified. In some cases, it is therefore not possible to predict the result of macro expansion.

The use of ## can result in obscured code.

Message in Report

The # and ## preprocessor operators should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Preprocessing Directives
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 1.3|MISRA C:2012 Rule 20.11

MISRA C:2012 Rule 20.11

A macro parameter immediately following a # operator shall not immediately be followed by a ## operator

Description

Rule Definition

A macro parameter immediately following a # operator shall not immediately be followed by a ## operator.

Rationale

The order of evaluation associated with multiple #, multiple ##, or a mix of # and ## preprocessor operators, is unspecified. Rule 20.10 discourages the use of # and ##. The result of a # operator is a string literal. It is extremely unlikely that pasting this result to any other preprocessing token results in a valid token.

Message in Report

The ## preprocessor operator shall not follow a macro parameter following a # preprocessor operator.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Use of # and

```
#define A( x )    #x             /* Compliant */
#define B( x, y ) x ## y         /* Compliant */
#define C( x, y ) #x ## y     /* Non-compliant */
```

In this example, you can see three uses of the # and ## operators. You can use these preprocessing operators alone (line 1 and line 2), but using # then ## is noncompliant (line 3).

Check Information

Group: Preprocessing Directives
Category: Required
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Rule 20.10

MISRA C:2012 Rule 20.12

A macro parameter used as an operand to the # or ## operators, which is itself subject to further macro replacement, shall only be used as an operand to these operators

Description

Rule Definition

A macro parameter used as an operand to the # or ## operators, which is itself subject to further macro replacement, shall only be used as an operand to these operators.

Rationale

The parameter to # or ## is not expanded prior to being used. The same parameter appearing elsewhere in the replacement text is expanded. If the macro parameter is itself subject to macro replacement, its use in mixed contexts within a macro replacement might not meet developer expectations.

Message in Report

Expanded macro parameter *`param1`* is also an operand of *`op`* operator.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Preprocessing Directives
Category: Required
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Rule 20.13

A line whose first token is # shall be a valid preprocessing directive

Description

Rule Definition

A line whose first token is # shall be a valid preprocessing directive

Rationale

You typically use a preprocessing directive to conditionally exclude source code until a corresponding `#else`, `#elif`, or `#endif` directive is encountered. If your compiler does not detect a preprocessing directive because it is malformed or invalid, you can end up excluding more code than you intended.

If all preprocessing directives are syntactically valid, even in excluded code, this unintended code exclusion cannot happen.

Message in Report

Directive is not syntactically meaningful.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Preprocessing Directives
Category: Required
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Rule 20.14

All #else, #elif and #endif preprocessor directives shall reside in the same file as the #if, #ifdef or #ifndef directive to which they are related

Description

Rule Definition

All #else, #elif and #endif preprocessor directives shall reside in the same file as the #if, #ifdef or #ifndef directive to which they are related.

Rationale

When conditional compilation directives include or exclude blocks of code and are spread over multiple files, confusion arises. If you terminate an `#if` directive within the same file, you reduce the visual complexity of the code and the chances of an error.

If you terminate `#if` directives within the same file, you can use `#if` directives in included files

Message in Report

- '#else' not within a conditional.
- '#elseif' not within a conditional.
- '#endif' not within a conditional.

  Unterminated conditional directive.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Preprocessing Directives
Category: Required
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Rule 20.2

The ', " or \ characters and the /* or // character sequences shall not occur in a header file name

Description

Rule Definition

The ', " or \ characters and the / or // character sequences shall not occur in a header file name*.

Rationale

The program's behavior is undefined if:

- You use `'`, `"`, `\`, `/*` or `//` between `<` `>` delimiters in a header name preprocessing token.
- You use `'`, `\`, `/*` or `//` between `"` delimiters in a header name preprocessing token.

Although `\` results in undefined behavior, many implementations accept `/` in its place.

Polyspace Implementation

Polyspace flags the characters `'`, `"`, `\`, `/*` or `//` between `<` and `>` in `#include <filename>`.

Polyspace flags the characters `'`, `\`, `/*` or `//` between `"` and `"` in `#include "filename"`.

Message in Report

The ', "or \ characters and the /* or // character sequences shall not occur in a header file name.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Preprocessing Directives
Category: Required
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Rule 20.3

The #include directive shall be followed by either a <filename> or \"filename\" sequence

Description

Rule Definition

The #include directive shall be followed by either a <filename> or "filename" sequence.

Rationale

This rule applies only after macro replacement.

The behavior is undefined if an `#include` directive does not use one of the following forms:

- `#include <filename>`
- `#include "filename"`

Message in Report

- '#include' expects \"FILENAME\" or <FILENAME>
- '#include_next' expects \"FILENAME\" or <FILENAME>
- '#include' does not expect string concatenation.
- '#include_next' does not expect string concatenation.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Preprocessing Directives
Category: Required
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Rule 20.4

A macro shall not be defined with the same name as a keyword

Description

Rule Definition

A macro shall not be defined with the same name as a keyword.

Rationale

Using macros to change the meaning of keywords can be confusing. The behavior is undefined if you include a standard header while a macro is defined with the same name as a keyword.

Message in Report

- The macro *`macro_name`* shall not be redefined.
- The macro *`macro_name`* shall not be undefined.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Redefining `int` keyword

```
#define int some_other_type
          /* Non-compliant - int keyword behavior altered */
#include <stdlib.h>
...
```

In this example, the `#define` violates Rule 20.4 because it alters the behavior of the `int` keyword. The inclusion of the standard header results in undefined behavior.

Correction — Rename keyword

One possible correction is to use a different keyword:

```
#define int_mine some_other_type
#include <stdlib.h>
...
```

Redefining keywords versus statements

```
#define while(E) for ( ; (E) ; )  /* Non-compliant - while redefined*/
#define unless(E) if ( !(E) )     /* Compliant*/

#define seq(S1, S2) do{ S1; S2;} while(false)  /* Compliant*/
#define compound(S) {S;}                       /* Compliant*/
...
```

In this example, it is noncompliant to redefine the keyword `while`, but it is compliant to define a macro that expands to statements.

Redefining keywords in different standards

```
#define inline
```

In this example, redefining `inline` is compliant in C90, but not in C99 because `inline` is not a keyword in C90.

Check Information

Group: Preprocessing Directives
Category: Required
AGC Category: Required
Languages: C90, C99

See Also

`MISRA C:2012 Rule 21.1`

MISRA C:2012 Rule 20.5

#undef should not be used

Description

Rule Definition

#undef should not be used.

Rationale

`#undef` can make the software unclear which macros exist at a particular point within a translation unit.

Message in Report

#undef shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Preprocessing Directives
Category: Advisory
AGC Category: Readability
Language: C90, C99

See Also

MISRA C:2012 Rule 20.6

Tokens that look like a preprocessing directive shall not occur within a macro argument

Description

Rule Definition

Tokens that look like a preprocessing directive shall not occur within a macro argument.

Rationale

An argument containing sequences of tokens that otherwise act as preprocessing directives leads to undefined behavior.

Polyspace Implementation

Polyspace looks for the # character in a macro arguments (outside a string or character constant).

Message in Report

Macro argument shall not look like a preprocessing directive.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Macro Expansion Causing Non-Compliance

```
#define M( A ) printf ( #A )
```

```
#include <stdio.h>

void foo(void){
    M(
#ifdef SW         /* Non-compliant */
    "Message 1"
#else
    "Message 2"   /* Compliant - SW not defined */
#endif            /* Non-compliant */
    );
}
```

This example shows a macro definition and the macro usage. `#ifdef SW` and `#endif` are noncompliant because they look like a preprocessing directive. Polyspace does not flag `#else "Message 2"` because after macro expansion, Polyspace knows `SW` is not defined. The expanded macro is `printf ("\"Message 2\"");`

Check Information

Group: Preprocessing Directives
Category: Required
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Rule 20.7

Expressions resulting from the expansion of macro parameters shall be enclosed in parentheses

Description

Rule Definition

Expressions resulting from the expansion of macro parameters shall be enclosed in parentheses.

Rationale

If you do not use parentheses, then it is possible that operator precedence does not give the results that you want when macro substitution occurs.

If you are not using a macro parameter as an expression, then the parentheses are not necessary because no operators are involved in the macro.

Message in Report

Expanded macro parameter *`param`* shall be enclosed in parentheses.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Macro Expressions

```
#define mac1(x, y) (x * y)
#define mac2(x, y) ((x) * (y))
```

```
void foo(void){
    int r;

    r = mac1(1 + 2, 3 + 4);       /* Non-compliant */
    r = mac1((1 + 2), (3 + 4));   /* Compliant */

    r = mac2(1 + 2, 3 + 4);       /* Compliant */
}
```

In this example, `mac1` and `mac2` are two defined macro expressions. The definition of `mac1` does not enclose the arguments in parentheses. In line 7, the macro expands to `r = (1 + 2 * 3 + 4);` This expression can be `(1 + (2 * 3) + 4)` or `(1 + 2) * (3 + 4)`. However, without parentheses, the program does not know the intended expression. Line 8 uses parentheses, so the line expands to `(1 + 2) * (3 + 4)`. This macro expression is compliant.

The definition of `mac2` does enclose the argument in parentheses. Line 10 (the same macro arguments in line 7) expands to `(1 + 2) * (3 + 4)`. This macro and macro expression are compliant.

Check Information

Group: Preprocessing Directives
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Dir 4.9`

MISRA C:2012 Rule 20.8

The controlling expression of a #if or #elif preprocessing directive shall evaluate to 0 or 1

Description

Rule Definition

The controlling expression of a #if or #elif preprocessing directive shall evaluate to 0 or 1.

Rationale

Strong typing requires that conditional inclusion preprocessing directives, `#if` or `#elif`, have a controlling expression that evaluates to a Boolean value.

Message in Report

The controlling expression of a #if or #elif preprocessing directive shall evaluate to 0 or 1.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Preprocessing Directives
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 14.4

MISRA C:2012 Rule 20.9

All identifiers used in the controlling expression of #if or #elif preprocessing directives shall be #define'd before evaluation

Description

Rule Definition

All identifiers used in the controlling expression of #if or #elif preprocessing directives shall be #define'd before evaluation.

Rationale

If attempt to use a macro identifier in a preprocessing directive, and you have not defined that identifier, then the preprocessor assumes that it has a value of zero. This value might not meet developer expectations.

Message in Report

`Identifier` is not defined.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Macro Identifiers

```
#if M == 0                    /* Non-compliant - Not defined */
#endif
```

```
#if defined (M)              /* Compliant - M is not evaluate */
#if M == 0                   /* Compliant - M is known to be defined */
#endif
#endif

#if defined (M) && (M == 0)  /* Compliant
                              * if M defined, M evaluated in ( M == 0 ) */
#endif
```

This example shows various uses of `M` in preprocessing directives. The second and third `#if` clauses check to see if the software defines `M` before evaluating `M`. The first `#if` clause does not check to see if `M` is defined, and because `M` is not defined, the statement is noncompliant.

Check Information

Group: Preprocessing Directives
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Dir 4.9`

MISRA C:2012 Rule 21.1

#define and #undef shall not be used on a reserved identifier or reserved macro name

Description

Rule Definition

#define and #undef shall not be used on a reserved identifier or reserved macro name.

Rationale

Reserved identifiers and reserved macro names are intended for use by the implementation. Removing or changing the meaning of a reserved macro can result in undefined behavior. This rule applies to the following:

- Identifiers or macro names beginning with an underscore
- Identifiers in file scope described in the C Standard Library (ISO/IEC 9899:1999, Section 7, "Library")
- Macro names described in the C Standard Library as being defined in a standard header (ISO/IEC 9899:1999, Section 7, "Library").

Message in Report

- The macro *`macro_name`* shall not be redefined.
- The macro *`macro_name`* shall not be undefined.
- The macro *`macro_name`* shall not be defined.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Defining or Undefining Reserved Identifiers

```
#undef __LINE__                /* Non-compliant - begins with _ */
#define _Guard_H 1             /* Non-compliant - begins with _ */
#undef _ BUILTIN_sqrt         /* Non-compliant - implementation may
                                 * use _BUILTIN_sqrt for other purposes,
                                 * e.g. generating a sqrt instruction */
#define defined               /* Non-compliant - reserved identifier */
#define errno my_errno        /* Non-compliant - library identifier */
#define isneg(x) ( (x) < 0 )  /* Compliant - rule doesn't include
                                 * future library directions   */
```

Check Information

Group: Standard Libraries
Category: Required
AGC Category: Required
Languages: C90, C99

See Also

MISRA C:2012 Rule 20.4

Introduced in R2014b

MISRA C:2012 Rule 21.10

The Standard Library time and date functions shall not be used

Description

Rule Definition

The Standard Library time and date functions shall not be used.

Rationale

Using these functions can cause unspecified, undefined and implementation-defined behavior.

Polyspace Implementation

If the function is a macro and the macro is expanded in the code, this rule is violated. It is assumed that rule 21.2 is not violated.

Message in Report

- The macro '<name> shall not be used.
- Identifier XX should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Standard Libraries
Category: Required

AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 21.11

The standard header file <tgmath.h> shall not be used

Description

Rule Definition

The standard header file <tgmath.h> shall not be used.

Rationale

Using the facilities of this header file can cause undefined behavior.

Polyspace Implementation

If the function is a macro and the macro is expanded in the code, this rule is violated. It is assumed that rule 21.2 is not violated.

Message in Report

- The macro '<name> shall not be used.
- Identifier XX should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Use of Function in `tgmath.h`

```
#include <tgmath.h>

float f1,res;


void func(void) {
    res = sqrt(f1); /* Non-compliant */
}
```

In this example, the rule is violated when the `sqrt` macro defined in `tgmath.h` is used.

Correction — Use Appropriate Function in `math.h`

For this example, one possible correction is to use the function `sqrtf` defined in `math.h` for `float` arguments.

```
#include <math.h>

float f1, res;


void func(void) {
 res = sqrtf(f1);
}
```

Check Information

Group: Standard Libraries
Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 21.12

The exception handling features of <fenv.h> should not be used

Description

Rule Definition

The exception handling features of <fenv.h> should not be used.

Rationale

In some cases, the values of the floating-point status flags are unspecified. Attempts to access them can cause undefined behavior.

Message in Report

The exception handling features of <fenv.h> should not be used

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Use of Features in <fenv.h>

```
#include <fenv.h>

void func(float x, float y) {
    float z;

    feclearexcept(FE_DIVBYZERO);              /* Non-compliant */
```

```
    z = x/y;

    if(fetestexcept (FE_DIVBYZERO))  {        /* Non-compliant */
    }
    else {
#pragma STDC FENV_ACCESS ON
        z=x*y;
        if(z>x) {
#pragma STDC FENV_ACCESS OFF
            if(fetestexcept (FE_OVERFLOW)) {  /* Non-compliant */
            }
        }
    }
}
```

In this example, the rule is violated when the identifiers `feclearexcept` and `fetestexcept`, and the macros `FE_DIVBYZERO` and `FE_OVERFLOW` are used.

Check Information

Group: Standard libraries
Category: Advisory
AGC Category: Advisory
Language: C99

See Also

Introduced in R2015b

MISRA C:2012 Rule 21.13

Any value passed to a function in <ctype.h> shall be representable as an `unsigned char` or be the value EOF

Description

Rule Definition

Any value passed to a function in <ctype.h> shall be representable as an `unsigned char` or be the value EOF.

Rationale

Functions in <ctype.h> have a well-defined behavior only for `int` arguments whose value is within the range of `unsigned char` or the negative value equivalent of `EOF`. The use of other values results in undefined behavior.

Polyspace Implementation

Polyspace considers that the negative value equivalent of EOF is -1 and does not raise a violation if you pass -1 as argument to a function in `ctype.h`.

Message in Report

Any value passed to a function in <ctype.h> shall be representable as an `unsigned char` or be the value `EOF`.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Invalid Arguments for Functions from <ctype.h>

```
bool_t f (uint8_t a)
{
    return (         isdigit ((int32_t) a  )     /* Compliant     */
                &&  isalpha ((int32_t) 'b')     /* Compliant     */
                &&  islower (          EOF)     /* Compliant     */
                &&  isalpha (          256));   /* Non-compliant */
}
```

In this example, the rule is violated when `256`, which is an neither an `unsigned char` or the value `EOF`, is passed as an input argument to the `isalpha` function.

Note The `int` casts in the above example are required to comply with Rule 10.3 on page 2-17.

Check Information

Group: Standard libraries
Category: Mandatory
AGC Category: Mandatory
Language: C90, C99

See Also

`MISRA C:2012 Rule 10.3`

Introduced in R2017a

MISRA C:2012 Rule 21.14

The Standard Library function `memcmp` shall not be used to compare null terminated strings

Description

Rule Definition

The Standard Library function `memcmp` shall not be used to compare null terminated strings.

Rationale

If `memcmp` is used to compare two strings and the length of either string is less than the number of bytes compared, the strings can appear different even when they are logically the same. The characters after the null terminator are compared even though they do not form part of the string.

For instance:

```
memcmp(string1, string2, sizeof(string1))
```

can compare bytes after the null terminator if `string1` is longer than `string2`.

Message in Report

The Standard Library function `memcmp` shall not be used to compare null terminated strings.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Using `memcmp` for String Comparison

```
extern char buffer1[ 12 ];
extern char buffer2[ 12 ];
void f1 ( void )
{
    ( void ) strcpy ( buffer1, "abc" );
    ( void ) strcpy ( buffer2, "abc" );
    if ( memcmp ( buffer1, buffer2, sizeof ( buffer1 ) ) != 0 )
    {
        /* Non-compliant */
    }
}
```

In this example, the comparison in the `if` statement is noncompliant. The strings stored in `buffer1` and `buffer2` can be reported different, but this difference comes from uninitialized characters after the null terminators.

Check Information

Group: Standard libraries
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 21.15|MISRA C:2012 Rule 21.16`

Introduced in R2017a

MISRA C:2012 Rule 21.15

The pointer arguments to the Standard Library functions `memcpy`, `memmove` and `memcmp` shall be pointers to qualified or unqualified versions of compatible types

Description

Rule Definition

The pointer arguments to the Standard Library functions `memcpy`, `memmove` and `memcmp` shall be pointers to qualified or unqualified versions of compatible types.

Rationale

The functions

```
memcpy( arg1, arg2, num_bytes );
memmove( arg1, arg2, num_bytes );
memcmp( arg1, arg2, num_bytes );
```

perform a byte-by-byte copy, move or comparison between the memory locations that `arg1` and `arg2` point to. A byte-by-byte copy, move or comparison is meaningful only if `arg1` and `arg2` have compatible types.

Using pointers to different data types for `arg1` and `arg2` typically indicates a coding error.

Message in Report

The pointer arguments to the Standard Library functions `memcpy`, `memmove` and `memcmp` shall be pointers to qualified or unqualified versions of compatible types.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Incompatible Argument Types for `memcpy`

```
void f ( uint8_t s1[ 8 ], uint16_t s2[ 8 ] )
{
    ( void ) memcpy ( s1, s2, 8 ); /* Non-compliant */
}
```

In this example, `s1` and `s2` are pointers to different data types. The `memcpy` statement copies eight bytes from one buffer to another.

Eight bytes represent the entire span of the buffer that `s1` points to, but only part of the buffer that `s2` points to. Therefore, the `memcpy` statement copies only part of `s2` to `s1`, which might be unintended.

Check Information

Group: Standard libraries
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 21.16`

Introduced in R2017a

MISRA C:2012 Rule 21.16

The pointer arguments to the Standard Library function `memcmp` shall point to either a pointer type, an essentially signed type, an essentially unsigned type, an essentially Boolean type or an essentially enum type

Description

Rule Definition

The pointer arguments to the Standard Library function `memcmp` shall point to either a pointer type, an essentially signed type, an essentially unsigned type, an essentially Boolean type or an essentially enum type.

Rationale

The Standard Library function

```
memcmp ( lhs, rhs, num );
```

performs a byte-by-byte comparison of the first `num` bytes of the two objects that `lhs` and `rhs` point to.

Do not use `memcmp` for a byte-by-byte comparison of the following.

Type	Rationale
Structures	If members of a structure have different data types, your compiler introduces additional padding for data alignment in memory. The content of these extra padding bytes is meaningless. If you perform a byte-by-byte comparison of structures with `memcmp`, you compare even the meaningless data stored in the padding. You might reach the false conclusion that two data structures are not equal, even if their corresponding members have the same value.

Type	Rationale
Objects with essentially floating type	The same floating point value can be stored using different representations. If you perform a byte-by-byte comparison of two variables with `memcmp`, you can reach the false conclusion that the variables are unequal even when they have the same value. The reason is that the values are stored using two different representations.
Essentially char arrays	Essentially char arrays are typically used to store strings. In strings, the content in bytes after the null terminator is meaningless. If you perform a byte-by-byte comparison of two strings with `memcmp`, you might reach the false conclusion that two strings are not equal, even if the bytes before the null terminator store the same value.

Message in Report

The pointer arguments to the Standard Library function `memcmp` shall point to either a pointer type, an *essentially signed* type, an *essentially unsigned* type, an *essentially Boolean* type or an *essentially enum* type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Using `memcmp` for Comparison of Structures, Unions, and *essentially char* Arrays

```
struct S;
bool_t f1 ( struct S *s1, struct S *s2 )
{
        return ( memcmp ( s1, s2, sizeof ( struct S ) ) != 0 ); /* Non-compliant */
}

union U
{
uint32_t range;
```

```
uint32_t height;
};
bool_t f2 ( union U *u1, union U *u2 )
{
        return ( memcmp ( u1, u2, sizeof ( union U ) ) != 0 ); /* Non-compliant */
}

const char a[ 6 ] = "task";
bool_t f3 ( const char b[ 6 ] )
{
        return ( memcmp ( a, b, 6 ) != 0 ); /* Non-compliant */
}
```

In this example:

- Structures `s1` and `s2` are compared in the `bool_t f1` function. The return value of this function might indicate that `s1` and `s2` are different due to padding. This comparison is noncompliant.
- Unions `u1` and `u2` are compared in the `bool_t f2` function. The return value of this function might indicate that `u1` and `u2` are the same due to unintentional comparison of `u1.range` and `u2.height`, or `u1.height` and `u2.range`. This comparison is noncompliant.
- Essentially char arrays `a` and `b` are compared in the `bool_t f3` function. The return value of this function might incorrectly indicate that the strings are different because the length of `a` (four) is less than the number of bytes compared (six). This comparison is noncompliant.

Check Information

Group: Standard libraries
Category: Required
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Rule 21.15

Introduced in R2017a

MISRA C:2012 Rule 21.17

Use of the string handling function from `<string.h>` shall not result in accesses beyond the bounds of the objects referenced by their pointer parameters

Description

Rule Definition

Use of the string handling function from `<string.h>` shall not result in accesses beyond the bounds of the objects referenced by their pointer parameters.

Rationale

Incorrect use of a string handling function might result in a read or write access beyond the bounds of the function arguments, resulting in undefined behavior.

Message in Report

Use of the string handling function from `<string.h>` shall not result in accesses beyond the bounds of the objects referenced by their pointer parameters.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Pointer Access Out of Bounds from `strcpy` Usage

```
char string[] = "Short";
void f1 ( const char *str )
{
```

```
        ( void ) strcpy ( string, "Too long to fit" );              /* Non-compliant */
        if ( strlen ( str ) < ( sizeof ( string ) - 1u ) )
        {
            ( void ) strcpy ( string, str );                         /* Compliant */
        }
}

size_t f2 ( void )
{
        char text[ 5 ] = "Token";
        return strlen ( text );                                     /* Non-compliant */
}
```

In this example:

- The first use of `strcpy` is noncompliant because it attempts to write beyond the end of its destination argument `string`.
- The second use of `strcpy` is compliant because it attempts to write to the destination argument `string` only if the source argument `str` fits.
- The use of `strlen` is noncompliant. `strlen` computes the length of a string up to the null terminator. The character array `text` has no null terminator.

Check Information

Group: Standard libraries
Category: Mandatory
AGC Category: Mandatory
Language: C90, C99

See Also

MISRA C:2012 Rule 21.18

Introduced in R2017a

MISRA C:2012 Rule 21.18

The `size_t` argument passed to any function in `<string.h>` shall have an appropriate value

Description

Rule Definition

The `size_t` argument passed to any function in `<string.h>` shall have an appropriate value.

Rationale

The value must be positive and not greater than the size of the smallest object passed by pointer to the function. For instance, suppose you use the `strncmp` function to compare two strings `lhs_string` and `rhs_string` as follows:

```
strncmp (lhs_string, rhs_string, num)
```

The third argument `num` must be positive and must not be greater than the size of `lhs_string` or `rhs_string`, whichever is smaller.

Otherwise, using the function can result in read or write access beyond the bounds of the function argument.

Message in Report

The `size_t` argument passed to any function in `<string.h>` shall have an appropriate value.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Incorrect `size_t` Argument for `memcmp`

```
char buf1[ 5 ] = "12345";
char buf2[ 10 ] = "1234567890";

void f ( void )
{
        if ( memcmp ( buf1, buf2, 5 ) == 0 )
        {
            /* Compliant */
        }
        if ( memcmp ( buf1, buf2, 6 ) == 0 )
        {
            /* Non-compliant */
        }
}
```

In this example, the first `if` statement is compliant. The `size_t` argument is five, which is same as the size of the smaller string, `buf1`.

By the same reasoning, the second `if` statement is noncompliant.

Check Information

Group: Standard libraries
Category: Mandatory
AGC Category: Mandatory
Language: C90, C99

See Also

MISRA C:2012 Rule 21.17

Introduced in R2017a

MISRA C:2012 Rule 21.19

The pointers returned by the Standard Library functions `localeconv`, `getenv`, `setlocale` or `strerror` shall only be used as if they have pointer to `const`-qualified type

Description

Rule Definition

The pointers returned by the Standard Library functions `localeconv`, `getenv`, `setlocale` or `strerror` shall only be used as if they have pointer to `const`-qualified type.

Rationale

The C99 Standard states that if the program modifies the structure pointed to by the value returned by `localeconv`, or the strings returned by `getenv`, `setlocale` or `strerro`, undefined behavior occurs. Treating the pointers returned by the various functions as if they were `const`-qualified allows an analysis tool to detect any attempt to modify an object through one of the pointers. Assigning the return values of the functions to `const`-qualified pointers results in the compiler issuing a diagnostic if an attempt is made to modify an object.

Message in Report

The pointers returned by the Standard Library functions `localeconv`, `getenv`, `setlocale` or `strerror` shall only be used as if they have pointer to `const`-qualified type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Returning Pointers from `setlocale` and `localeconv`

```
void f1 ( void )
{
        char *s1 = setlocale ( LC_ALL, 0 ); /* Non-compliant */
        struct lconv *conv = localeconv (); /* Non-compliant */
        s1[ 1 ] = 'A'; /* Undefined behavior */
        conv->decimal_point = "^"; /* Undefined behavior */
}

void f2 ( void )
{
        char str[128];
        (void) strcpy (str, setlocale ( LC_ALL,0 ) ); /* Compliant */
        const struct lconv *conv = localeconv ();     /* Compliant */
        conv->decimanl_point = "^"                    /* Constraint violation */
}

void f3 ( void )
{
const struct lconv *conv = localeconv (); /* Compliant */
conv->grouping[ 2 ] = 'x';                /* Non-compliant */
}
```

In the above example:

- The usage of `setlocale` and `localeconv` in the function `f1` are non-compliant as the returned pointers are assigned to non-`const`—qualified pointers.

  Note The usage of `setlocale` and `localeconv` above are not constraint violations and will therefore not be reported by a compiler. However, an analysis tool will be able to report a violation.

- The usage of `setlocale` in the function `f2` is compliant as `strcpy` takes a `const char *` as its second parameter. The usage of `localeconv` in the function `f2` is compliant as the returned pointers are assigned to a `const`-qualified pointer. Any attempt to modify an object through a pointer will be reported by a compiler or analysis tool as this is a constraint violation.

- The usage of a `const`-qualified pointer in the function `f3` gives compile time protection of the value returned by `localeconv` but the same is not true for the strings it references. Modification of these strings can be detected by an analysis tool.

Check Information

Group: Standard libraries
Category: Mandatory
AGC Category: Mandatory
Language: C90, C99

See Also

`MISRA C:2012 Rule 7.4|MISRA C:2012 Rule 11.8|MISRA C:2012 Rule 21.8`

Introduced in R2017a

MISRA C:2012 Rule 21.2

A reserved identifier or macro name shall not be declared

Description

Rule Definition

A reserved identifier or macro name shall not be declared.

Rationale

The Standard allows implementations to treat reserved identifiers specially. If you reuse reserved identifiers, you can cause undefined behavior.

Polyspace Implementation

- If you define a macro name that corresponds to a standard library macro, object, or function, rule 21.1 is violated.
- The rule considers tentative definitions as definitions.

Message in Report

Identifier 'XX' shall not be reused.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Standard Libraries
Category: Required

AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 21.20

The pointer returned by the Standard Library functions `asctime`, `ctime`, `gmtime`, `localtime`, `localeconv`, `getenv`, `setlocale` or `strerror` shall not be used following a subsequent call to the same function

Description

Rule Definition

The pointer returned by the Standard Library functions `asctime`, `ctime`, `gmtime`, `localtime`, `localeconv`, `getenv`, `setlocale` or `strerror` shall not be used following a subsequent call to the same function.

Rationale

The preceding functions return a pointer to an object within the Standard Library. Implementation for this object can use a static buffer that can be modified by a second call to the same function. Therefore the value accessed through a pointer before a subsequent call to the same function can change unexpectedly.

Message in Report

The pointer returned by the Standard Library functions `asctime`, `ctime`, `gmtime`, `localtime`, `localeconv`, `getenv`, `setlocale` or `strerror` shall not be used following a subsequent call to the same function.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Use of Return Value from getenv After Another Call to getenv

```
void f1( void )
{
        const char *res1;
        const char *res2;
        char copy[ 128 ];
        res1 = setlocale ( LC_ALL, 0 );
        ( void ) strcpy ( copy, res1 );
        res2 = setlocale ( LC_MONETARY, "French" );
        printf ( "%s\n", res1 ); /* Non-compliant */
        printf ( "%s\n", copy ); /* Compliant */
        printf ( "%s\n", res2 ); /* Compliant */
}
```

In this example:

- The first `printf` statement is non-compliant because the pointer returned by `setlocale` is used following a subsequent call to it when `res2` is assigned.
- The second `printf` statement is compliant because the copy operation performed by `strcpy` is made before a subsequent call to `setlocale` function is made.
- The third `printf` statement is compliant because there is no subsequent call to the `setlocale` function is made before use.

Check Information

Group: Standard libraries
Category: Mandatory
AGC Category: Mandatory
Language: C90, C99

See Also

Introduced in R2017a

MISRA C:2012 Rule 21.3

The memory allocation and deallocation functions of <stdlib.h> shall not be used

Description

Rule Definition

The memory allocation and deallocation functions of <stdlib.h> shall not be used.

Rationale

Using memory allocation and deallocation routines can cause undefined behavior. For instance:

- You free memory that you had not allocated dynamically.
- You use a pointer that points to a freed memory location.

Polyspace Implementation

If you use names of dynamic heap memory allocation functions for macros, and you expand the macros in the code, this rule is violated. It is assumed that rule 21.2 is not violated.

Message in Report

- The macro <name> shall not be used.
- Identifier XX should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Use of `malloc`, `calloc`, `realloc` and `free`

```
#include <stdlib.h>

static int foo(void);

typedef struct struct_1 {
    int a;
    char c;
} S_1;

static int foo(void) {

    _S_1 * ad_1;
    int  * ad_2;
    int  * ad_3;

    ad_1 = (S_1*)calloc(100U, sizeof(S_1));        /* Non-compliant */
    ad_2 = malloc(100U * sizeof(int));             /* Non-compliant */
    ad_3 = realloc(ad_3, 60U * sizeof(long));      /* Non-compliant */

    free(ad_1);                                    /* Non-compliant */
    free(ad_2);                                    /* Non-compliant */
    free(ad_3);                                    /* Non-compliant */

    return 1;
}
```

In this example, the rule is violated when the functions `malloc`, `calloc`, `realloc` and `free` are used.

Check Information

Group: Standard Libraries
Category: Required
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Rule 18.7

Introduced in R2014b

MISRA C:2012 Rule 21.4

The standard header file <setjmp.h> shall not be used

Description

Rule Definition

The standard header file <setjmp.h> shall not be used.

Rationale

Using `setjmp` and `longjmp`, you can bypass normal function call mechanisms and cause undefined behavior.

Polyspace Implementation

If the `longjmp` function is a macro and the macro is expanded in the code, this rule is violated. It is assumed that rule 21.2 is not violated.

Message in Report

- The macro '<name> shall not be used.
- Identifier XX should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Standard Libraries
Category: Required

AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 21.5

The standard header file <signal.h> shall not be used

Description

Rule Definition

The standard header file <signal.h> shall not be used.

Rationale

Using signal handling functions can cause implementation-defined and undefined behavior.

Polyspace Implementation

If the signal function is a macro and the macro is expanded in the code, this rule is violated. It is assumed that rule 21.2 is not violated.

Message in Report

- The macro '<name> shall not be used.
- Identifier XX should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Standard Libraries
Category: Required

AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 21.6

The Standard Library input/output functions shall not be used

Description

Rule Definition

The Standard Library input/output functions shall not be used.

Rationale

This rule applies to the functions that are provided by `<stdio.h>` and in C99, their character-wide equivalents provided by `<wchar.h>`. Using these functions can cause unspecified, undefined and implementation-defined behavior.

Polyspace Implementation

If the Standard Library function is a macro and the macro is expanded in the code, this rule is violated. It is assumed that rule 21.2 is not violated.

Message in Report

- The macro '<name> shall not be used.
- Identifier XX should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Standard Libraries

Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 21.7

The `atof`, `atoi`, `atol`, and `atoll` functions of `<stdlib.h>` shall not be used

Description

Rule Definition

The atof, atoi, atol, and atoll functions of <stdlib.h> shall not be used.

Rationale

When a string cannot be converted, the behavior of these functions can be undefined.

Polyspace Implementation

If the function is a macro and the macro is expanded in the code, this rule is violated. It is assumed that rule 21.2 is not violated.

Message in Report

- The macro '<name> shall not be used.
- Identifier XX should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Standard Libraries
Category: Required
AGC Category: Required

Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 21.8

The library functions abort, exit, getenv and system of <stdlib.h> shall not be used

Description

Rule Definition

The library functions abort, exit, getenv and system of <stdlib.h> shall not be used.

Rationale

Using these functions can cause undefined and implementation-defined behaviors.

Polyspace Implementation

In case the abort, exit, getenv, and system functions are actually macros, and the macros are expanded in the code, this rule is detected as violated. It is assumed that rule 21.2 is not violated.

Message in Report

- The macro '<name> shall not be used.
- Identifier XX should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Standard Libraries
Category: Required

AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 21.9

The library functions bsearch and qsort of <stdlib.h> shall not be used

Description

Rule Definition

The library functions bsearch and qsort of <stdlib.h> shall not be used.

Rationale

The comparison function in these library functions can behave inconsistently when the elements being compared are equal. Also, the implementation of `qsort` can be recursive and place unknown demands on the call stack.

Polyspace Implementation

If the function is a macro and the macro is expanded in the code, this rule is violated. It is assumed that rule 21.2 is not violated.

Message in Report

- The macro '<name> shall not be used.
- Identifier XX should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Standard Libraries

Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 22.1

All resources obtained dynamically by means of Standard Library functions shall be explicitly released

Description

Rule Definition

All resources obtained dynamically by means of Standard Library functions shall be explicitly released.

Rationale

Resources are something that you must return to the system once you have used them. Examples include dynamically allocated memory and file descriptors.

If you do not release resources explicitly as soon as possible, then a failure can occur due to exhaustion of resources.

Polyspace Implementation

You can check for this rule with a Bug Finder analysis only.

Message in Report

All resources obtained dynamically by means of Standard Library functions shall be explicitly released.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Dynamic Memory

```
#include<stdlib.h>


void performOperation(int);

int func1(int num) {
    int *arr1 = (int*) malloc(num * sizeof(int));

    return 0;
}           /* Non-compliant - memory allocated to arr1 is not released */

int func2(int num) {
    int *arr2 = (int*) malloc(num * sizeof(int));

    free(arr2);
    return 0;
}          /* Compliant - memory allocated to arr2 is released */
```

In this example, the rule is violated when memory dynamically allocated using the `malloc` function is not freed using the `free` function before the end of scope.

File Pointers

```
#include <stdio.h>
void func1( void ) {
    FILE *fp1;
    fp1 = fopen ( "data1.txt", "w" );
    fprintf ( fp1, "*" );

    fp1 = fopen ( "data2.txt", "w" );              /* Non-compliant */
    fprintf ( fp1, "!" );
    fclose ( fp1 );
}

void func2( void ) {
    FILE *fp2;
    fp2 = fopen ( "data1.txt", "w" );
```

```
    fprintf ( fp2, "*" );
    fclose(fp2);

    fp2 = fopen ( "data2.txt", "w" );              /* Compliant */
    fprintf ( fp2, "!" );
    fclose ( fp2 );
}
```

In this example, the file pointer `fp1` is pointing to a file `data1.txt`. Before `fp1` is explicitly dissociated from the file stream of `data1.txt`, it is used to access another file `data2.txt`. Therefore, the rule 22.1 is violated.

The rule is not violated in `func2` because file `data1.txt` is closed and the file pointer `fp2` is explicitly dissociated from `data1.txt` before it is reused.

Check Information

Group: Resources
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Dir 4.13|MISRA C:2012 Rule 21.3|MISRA C:2012 Rule 21.6|Resource leak`

Introduced in R2015b

MISRA C:2012 Rule 22.10

The value of `errno` shall only be tested when the last function to be called was an `errno`-setting function

Description

Rule Definition

The value of `errno` shall only be tested when the last function to be called was an `errno`-setting function.

Rationale

Besides the `errno`-setting functions, the Standard does not enforce that other functions set `errno` on errors. Whether these functions set `errno` or not is implementation-dependent.

To detect errors, if you check `errno` alone, the validity of this check also becomes implementation-dependent. On implementations that do not require `errno` setting, even if you check `errno` alone, you can overlook error conditions.

For a list of `errno`-setting functions, see `MISRA C:2012 Rule 22.8`.

Message in Report

The value of `errno` shall only be tested when the last function to be called was an `errno`-setting function.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Incorrect Test of `errno`

```
void f ( void )
{
    float64_t f64;
    errno = 0;
    f64 = atof ( "A.12" );
    if ( 0 == errno ) /* Non-compliant */
    {
    }
    errno = 0;
    f64 = strtod ( "A.12", NULL );
    if ( 0 == errno ) /* Compliant */
    {
    }
}
```

In this example:

- The first `if` statement is noncompliant because `atof` may or may not set `errno` when an error is detected. `f64` may not have a valid value within this `if` statement.
- The second `if` statement is compliant because `strtod` is an *`errno`-setting function*. `f64` will have a valid value within this `if` statement.

Check Information

Group: Resources
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 22.8` | `MISRA C:2012 Rule 22.9`

Introduced in R2017a

MISRA C:2012 Rule 22.2

A block of memory shall only be freed if it was allocated by means of a Standard Library function

Description

Rule Definition

A block of memory shall only be freed if it was allocated by means of a Standard Library function.

Rationale

The Standard Library functions that allocate memory are `malloc`, `calloc` and `realloc`.

You free a block of memory when you pass its address to the `free` or `realloc` function. The following causes undefined behavior:

- You free a block of memory that you did not allocate.
- You free a block of memory that have already freed before.

Polyspace Implementation

You can check for this rule with a Bug Finder analysis only.

Message in Report

A block of memory shall only be freed if it was allocated by means of a Standard Library function.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Memory Not Allocated Is Freed

```
#include <stdlib.h>

void func1(void) {
    int x=0;
    int *ptr=&x;

    free(ptr);
   /* Non-compliant: ptr is not dynamically allocated */
}
```

In this example, the rule is violated because the `free` function operates on a pointer that does not point to dynamically allocated memory.

Memory Freed Twice

```
#include <stdlib.h>

void func(int arrSize) {
    int *ptr = (int*) malloc(arrSize* sizeof(int));

    free(ptr);   /* Block of memory freed once */
    free(ptr);   /* Non-compliant - Block of memory freed twice */
}
```

In this example, the rule is violated when the `free` function operates on `ptr` twice without a reallocation in between.

Check Information

Group: Resources
Category: Mandatory
AGC Category: Mandatory
Language: C90, C99

See Also

Deallocation of previously deallocated pointer|Invalid free of pointer|MISRA C:2012 Dir 4.13|MISRA C:2012 Rule 21.3

Introduced in R2015b

MISRA C:2012 Rule 22.3

The same file shall not be open for read and write access at the same time on different streams

Description

Rule Definition

The same file shall not be open for read and write access at the same time on different streams.

Rationale

If a file is both written and read via different streams, the behavior can be undefined.

Polyspace Implementation

You can check for this rule with a Bug Finder analysis only.

Message in Report

The same file shall not be open for read and write access at the same time on different streams.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Opening File That Is Open in Another Stream

```
#include <stdio.h>

void func(void) {
    FILE *fw = fopen("tmp.txt", "r+");
    FILE *fr = fopen("tmp.txt", "r");   /* Non-compliant: File open in stream fw*/
}
```

In this example, the rule is violated when the same file `tmp.txt` is opened in two streams. The `FILE` pointers `fw` and `fr` point to two different streams here.

Check Information

Group: Resources
Category: Required
AGC Category: Required
Language: C

See Also

`MISRA C:2012 Rule 21.6` | `Resource leak`

Introduced in R2015b

MISRA C:2012 Rule 22.4

There shall be no attempt to write to a stream which has been opened as read-only

Description

Rule Definition

There shall be no attempt to write to a stream which has been opened as read-only.

Rationale

The Standard does not specify the behavior if an attempt is made to write to a read-only stream.

Polyspace Implementation

You can check for this rule with a Bug Finder analysis only.

Message in Report

There shall be no attempt to write to a stream which has been opened as read-only.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Writing to File Opened as Read-Only

```
#include <stdio.h>
```

```
void func1(void) {
    FILE *fp1 = fopen("tmp.txt", "r");
    (void) fprintf(fp1, "Some text"); /* Non-compliant: Read-only stream */
    (void) fclose(fp1);
}

void func2(void) {
    FILE *fp2 = fopen("tmp.txt", "r+");
    (void) fprintf(fp2, "Some text"); /* Compliant */
    (void) fclose(fp2);
}
```

In this example, the file stream associated with `fp1` is opened as read-only. The rule is violated when the stream is written.

Check Information

Group: Resources
Category: Mandatory
AGC Category: Mandatory
Language: C90, C99

See Also

`MISRA C:2012 Rule 21.6|Writing to read-only resource`

Introduced in R2015b

MISRA C:2012 Rule 22.5

A pointer to a FILE object shall not be dereferenced

Description

Rule Definition

A pointer to a FILE object shall not be dereferenced.

Rationale

The Standard states that the address of a FILE object used to control a stream can be significant. Copying that object might not give the same behavior. This rule ensures that you cannot perform such a copy.

Directly manipulating a FILE object might be incompatible with its use as a stream designator.

Message in Report

A pointer to a FILE object shall not be dereferenced

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

FILE* Pointer Dereferenced

```
#include <stdio.h>
```

```
void func(void) {
    FILE *pf1;
    FILE *pf2;
    FILE f3;

    pf2 = pf1;        /* Compliant */
    f3 = *pf2;        /* Non-compliant */
    pf2->_flags=0;    /* Non-compliant */
 }
```

In this example, the rule is violated when the `FILE*` pointer `pf2` is dereferenced.

Check Information

Group: Resources
Category: Mandatory
AGC Category: Mandatory
Language: C90, C99

See Also

`MISRA C:2012 Rule 21.6`

Introduced in R2015b

MISRA C:2012 Rule 22.6

The value of a pointer to a `FILE` shall not be used after the associated stream has been closed

Description

Rule Definition

The value of a pointer to a `FILE` shall not be used after the associated stream has been closed.

Rationale

The Standard states that the value of a `FILE*` pointer is indeterminate after you close the stream associated with it.

Polyspace Implementation

You can check for this rule with a Bug Finder analysis only.

Message in Report

The value of a pointer to a `FILE` shall not be used after the associated stream has been closed.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Use of FILE Pointer After Closing Stream

```
#include <stdio.h>

void func(void) {
    FILE *fp;
    void *ptr;

    fp = fopen("tmp","w");
    if(fp != NULL) {
        fclose(fp);
        fprintf(fp,"text");
    }
}
```

In this example, the stream associated with the `FILE*` pointer `fp` is closed with the `fclose` function. The rule is violated `FILE*` pointer `fp` is used before the stream is re-opened.

Check Information

Group: Resources
Category: Mandatory
AGC Category: Mandatory
Language: C90, C99

See Also

`MISRA C:2012 Dir 4.13|MISRA C:2012 Rule 21.6|Use of previously closed resource`

Introduced in R2015b

MISRA C:2012 Rule 22.7

The macro EOF shall only be compared with the unmodified return value from any Standard Library function capable of returning EOF

Description

Rule Definition

The macro `EOF` shall only be compared with the unmodified return value from any Standard Library function capable of returning `EOF`.

Rationale

The `EOF` value may become indistinguishable from a valid character code if the value returned is converted to another type. In such cases, testing the converted value against `EOF` will not reliably identify if the end of the file has been reached or if an error has occurred.

Message in Report

The macro `EOF` shall only be compared with the unmodified return value from any Standard Library function capable of returning `EOF`.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Possibly Misleading Results from Comparison with EOF

```
void f1 ( void )
{
```

```
    char ch;
    ch = ( char ) getchar ();
    if ( EOF != ( int32_t ) ch )  /* Non-compliant */
    {
    }
}

void f2 ( void )
{
    char ch;
    ch = ( char ) getchar ();
    if ( !feof ( stdin ) )        /* Compliant */
    {
    }
}

void f3 ( void )
{
    int32_t i_ch;
    i_ch = getchar ();
    if ( EOF != i_ch )            /* Compliant */
     {
        char ch;
        ch = ( char ) i_ch;
    }
}
```

In this example:

- The test in the `f1` function is non-compliant. It will not be reliable as the return value is cast to a narrower type before checking for `EOF`.
- The test in the `f2` function is compliant. It shows how *`feof()`* can be used to check for `EOF` when the return value from *`getchar()`* has been subjected to type conversion.
- The test in the `f3` function is compliant. It is reliable as the unconverted return value is used when checking for `EOF`.

Check Information

Group: Resources
Category: Required
AGC Category: Required

Language: C90, C99

See Also

Introduced in R2017a

MISRA C:2012 Rule 22.8

The value of `errno` shall be set to zero prior to a call to an `errno`-setting-function

Description

Rule Definition

The value of `errno` shall be set to zero prior to a call to an `errno`-setting-function.

Rationale

If an error occurs during a call to an `errno`-setting-function, the function writes a nonzero value to `errno`. Otherwise, `errno` is not modified.

If you do not explicitly set `errno` to zero before a function call, it can contain values from a previous call. Checking `errno` for nonzero values after the function call can give the false impression that an error occurred.

`Errno`-setting functions include:

- `ftell`, `fgetpos`, `fgetwc` and related functions.
- `strtoimax`, `strtol` and related functions.

  The wide-character equivalents such as `wcstoimax` and `wcstol` are also covered.

Message in Report

The value of `errno` shall be set to zero prior to a call to an *`errno`-setting-function*.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

`errno` Not Reset Before Use

```
#include <stdlib.h>
#include <errno.h>

double val = 0.0;

void f ( void )
{
    val = strtod("1.0",NULL); /* Non-compliant */
    if ( 0 == errno ) /* Check errno for nonzero values */
    {
        val = strtod("1.0",NULL); /* Compliant - case 1*/
        if ( 0 == errno ) /* Check errno for nonzero values */
        {
        }
    }
    else
    {
        errno = 0;
        val = strtod("1.0",NULL); /* Compliant - case 2*/
        if ( 0 == errno ) /* Check errno for nonzero values */
        {
        }
    }
}
```

In this example, the rule is violated when `strtod` is called but `errno` is not reset prior to the call.

The rule is not violated in the following cases:

- Case 1: `errno` is compared against zero and then `strtod` is called in the `if( 0 == errno )` branch.
- Case 2: `errno` is explicitly set to zero and then `strtod` is called.

Check Information

Group: Resources

Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 22.9|MISRA C:2012 Rule 22.10`

Introduced in R2017a

MISRA C:2012 Rule 22.9

The value of `errno` shall be tested against zero after calling an `errno`-setting function

Description

Rule Definition

The value of `errno` shall be tested against zero after calling an `errno`-setting function.

Rationale

If an error occurs during a call to an `errno`-setting-function, the function writes a nonzero value to `errno`. Otherwise, `errno` is not modified.

When `errno` is nonzero, the function return value is not likely to be correct. Before using this return value, you must test `errno` for nonzero values.

`Errno`-setting functions include:

- `ftell`, `fgetpos`, `fgetwc` and related functions.
- `strtoimax`, `strtol` and related functions.

  The wide-character equivalents such as `wcstoimax` and `wcstol` are also covered.

Message in Report

The value of `errno` shall be tested against zero after calling an *`errno`-setting function*.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

`errno` Not Tested After Function Call

```
#include <stdlib.h>
#include <errno.h>

void func(void);
double val = 0.0;

void f1 ( void )
{
  errno = 0;
  val = strtod ( "1.0", NULL ); /* Non-compliant */
  func ();

  if ( 0 != errno )
    {
    }

  errno = 0;
  val = strtod ( "1.0", NULL ); /* Compliant */
  if ( 0 == errno )
    {
      func();
    }
}
```

In this example, the rule is violated when `errno` is not checked immediately after the first call to `strtod`. Instead, a second function `func` is called. `func` might use the value in the global variable `val`. The value can be incorrect if an error has occurred during the call to `strtod`.

The rule is not violated when `errno` is checked before operations that potentially use the return value of `strtod`.

Check Information

Group: Resources
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 22.8` | `MISRA C:2012 Rule 22.10`

Introduced in R2017a

MISRA C:2012 Rule 3.1

The character sequences /* and // shall not be used within a comment

Description

Rule Definition

The character sequences / and // shall not be used within a comment.*

Rationale

These character sequences are not allowed in code comments because:

- If your code contains a /* or a // in a /* */ comment, it typically means that you have inadvertently commented out code.
- If your code contains a /* in a // comment, it typically means that you have inadvertently uncommented a /* */ comment.

Polyspace Implementation

You cannot annotate this rule in the source code.

For information on annotations, see .

Message in Report

The character sequence /* shall not appear within a comment.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

/* Used in // Comments

```
int x;
int y;
int z;

void non_compliant_comments ( void )
{
    x = y //      /* Non-compliant
        + z
        //  */
        ;
    z++;    //    Compliant with exception: // permitted within a // comment
}

void compliant_comments ( void )
{
    x = y /*      Compliant
      + z
      */
        ;
    z++;    //    Compliant with exception: // is permitted within a // comment
}
```

In this example, in the `non_compliant_comments` function, the `/*` character occurs in what appears to be a `//` comment, violating the rule. Because of the comment structure, the operation that takes place is `x = y + z;`. However, without the two `//`-s, an entirely different operation `x=y;` takes place. It is not clear which operation is intended.

Use a comment format that makes your intention clear. For instance, in the `compliant_comments` function, it is clear that the operation `x=y;` is intended.

Check Information

Group: Comments
Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 3.2

Line-splicing shall not be used in `//` comments

Description

Rule Definition

Line-splicing shall not be used in // comments.

Rationale

Line-splicing occurs when the `\` character is immediately followed by a new-line character. Line splicing is used for statements that span multiple lines.

If you use line-splicing in a `//` comment, the following line can become part of the comment. In most cases, the `\` is spurious and can cause unintentional commenting out of code.

Message in Report

Line-splicing shall not be used in `//` comments.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Line Splicing in // Comment

```
#include <stdbool.h>
```

```
extern _Bool b;

void func ( void )
{
    unsigned short x = 0;   // Non-compliant - Line-splicing \
    if ( b )
    {
        ++b;
    }
}
```

Because of line-splicing, the statement `if ( b )` is a part of the previous `//` comment. Therefore, the statement `b++` always executes, making the `if` block redundant.

Check Information

Group: Comments
Category: Required
AGC Category: Required
Language: C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 4.1

Octal and hexadecimal escape sequences shall be terminated

Description

Rule Definition

Octal and hexadecimal escape sequences shall be terminated.

Rationale

There is potential for confusion if an octal or hexadecimal escape sequence is followed by other characters. For example, the character constant `'\x1f'` consists of a single character, whereas the character constant `'\x1g'` consists of the two characters `'\x1'` and `'g'`. The manner in which multi-character constants are represented as integers is implementation-defined.

If every octal or hexadecimal escape sequence in a character constant or string literal is terminated, you reduce potential confusion.

Message in Report

Octal and hexadecimal escape sequences shall be terminated.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Compliant and Noncompliant Escape Sequences

```
const char *s1 = "\x41g";     /* Non-compliant */
const char *s2 = "\x41" "g";  /* Compliant - Terminated by end of literal */
const char *s3 = "\x41\x67";  /* Compliant - Terminated by another escape sequence*/

int c1 = '\141t';             /* Non-compliant */
int c2 = '\141\t';            /* Compliant - Terminated by another escape sequence*/
```

In this example, the rule is violated when an escape sequence is not terminated with the end of string literal or another escape sequence.

Check Information

Group: Character Sets and Lexical Conventions
Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 4.2

Trigraphs should not be used

Description

Rule Definition

Trigraphs should not be used.

Rationale

You denote trigraphs with two question marks followed by a specific third character (for instance,`'??-'` represents a `'~'` (tilde) character and `'??)'` represents a `']'`). These trigraphs can cause accidental confusion with other uses of two question marks.

Note Digraphs (`<: :>`, `<% %>`, `%:`, `%:%:`) are permitted because they are tokens.

Polyspace Implementation

The Polyspace analysis converts trigraphs to the equivalent character for the . However, Polyspace also raises a MISRA violation.

The standard requires that trigraphs must be transformed *before* comments are removed during preprocessing. Therefore, Polyspace raises a violation of this rule even if a trigraph appears in code comments.

Message in Report

Trigraphs should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Character Sets and Lexical Conventions
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 5.1

External identifiers shall be distinct

Description

Rule Definition

External identifiers shall be distinct.

Rationale

External identifiers are ones declared with global scope or storage class `extern`.

Polyspace considers two names as distinct if there is a difference between their first 31 characters. If the difference between two names occurs only beyond the first 31 characters, they can be easily mistaken for each other. The readability of the code is reduced. For C90, the difference must occur between the first 6 characters. To use the C90 rules checking, use the value `c90` for the option `C standard version (-c-version)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Message in Report

External `%s %s` conflicts with the external identifier XX in file YY.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

C90: First Six Characters of Identifiers Not Unique

```
int engine_temperature_raw;
int engine_temperature_scaled;   /* Non-compliant */
int engin2_temperature;          /* Compliant */
```

In this example, the identifier `engine_temperature_scaled` has the same first six characters as a previous identifier, `engine_temperature_raw`.

C99: First 31 Characters of Identifiers Not Unique

```
int engine_exhaust_gas_temperature_raw;
int engine_exhaust_gas_temperature_scaled; /* Non-compliant */

int eng_exhaust_gas_temp_raw;
int eng_exhaust_gas_temp_scaled;           /* Compliant */
```

In this example, the identifier `engine_exhaust_gas_temperature_scaled` has the same first 31 characters as a previous identifier, `engine_exhaust_gas_temperature_raw`.

C90: First Six Characters Identifiers in Different Translation Units Differ in Case Alone

```
/* file1.c */
int abc = 0;

/* file2.c */
int ABC = 0; /* Non-compliant */
```

In this example, the implementation supports 6 significant case-insensitive characters in *external identifiers*. The identifiers in the two translation are different but are not distinct in their significant characters.

Check Information

Group: Identifiers

Category: Required
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Rule 5.2 | MISRA C:2012 Rule 5.4 | MISRA C:2012 Rule 5.5

Introduced in R2014b

MISRA C:2012 Rule 5.2

Identifiers declared in the same scope and name space shall be distinct

Description

Rule Definition

Identifiers declared in the same scope and name space shall be distinct.

Rationale

Polyspace considers two names as distinct if there is a difference between their first 63 characters. If the difference between two names occurs only beyond the first 63 characters, they can be easily mistaken for each other. The readability of the code is reduced. For C90, the difference must occur between the first 31 characters. To use the C90 rules checking, use the value `c90` for the option .

Message in Report

Identifier XX has same significant characters as identifier YY.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

C90: First 31 Characters of Identifiers Not Unique

```
extern int engine_exhaust_gas_temperature_raw;
static int engine_exhaust_gas_temperature_scaled;      /* Non-compliant */
```

```
extern double engine_exhaust_gas_temperature_raw;
static double engine_exhaust_gas_temperature2_scaled;  /* Compliant */

void func ( void )
{
  /* Not in the same scope */
  int engine_exhaust_gas_temperature_local;            /* Compliant */
}
```

In this example, the identifier `engine_exhaust_gas_temperature_scaled` has the same 31 characters as a previous identifier, `engine_exhaust_gas_temperature_raw`.

The rule does not apply if the two identifiers have the same 31 characters but have different scopes. For instance, `engine_exhaust_gas_temperature_local` has the same 31 characters as `engine_exhaust_gas_temperature_raw` but different scope.

C99: First 63 Characters of Identifiers Not Unique

```
extern int engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_x_raw;
static int engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_x_scale;
    /* Non-compliant */

extern int engine_gas_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx__raw;
static int engine_gas_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx__scale;
    /* Compliant */

void func ( void )
{
/* Not in the same scope */
    int engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_x_local;
          /* Compliant */
}
```

In this example, the identifier `engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_x_scale` has the same 63 characters as a previous identifier, `engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_x_raw`.

Check Information

Group: Identifiers

Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 5.1|MISRA C:2012 Rule 5.3|MISRA C:2012 Rule 5.4|MISRA C:2012 Rule 5.5`

Introduced in R2014b

MISRA C:2012 Rule 5.3

An identifier declared in an inner scope shall not hide an identifier declared in an outer scope

Description

Rule Definition

An identifier declared in an inner scope shall not hide an identifier declared in an outer scope.

Rationale

If two identifiers have the same name but different scope, the identifier in the inner scope hides the identifier in the outer scope. All uses of the identifier name refers to the identifier in the inner scope. This behavior forces the developer to keep track of the scope and reduces code readability.

Polyspace considers two names as distinct if there is a difference between their first 63 characters. If the difference between two names occurs only beyond the first 63 characters, they can be easily mistaken for each other. The readability of the code is reduced. For C90, the difference must occur between the first 31 characters. To use the C90 rules checking, use the value `c90` for the option .

Message in Report

Variable XX hides variable XX (FILE line LINE column COLUMN).

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Local Variable Hidden by Another Local Variable in Inner Block

```
typedef signed short int16_t;

void func( void )
{
    int16_t i;
    {
        int16_t i;                /* Non-compliant */
        i = 3;
    }
}
```

In this example, the identifier `i` defined in the inner block in `func` hides the identifier `i` with function scope.

It is not immediately clear to a reader which `i` is referred to in the statement `i=3`.

Global Variable Hidden by Function Parameter

```
typedef signed short int16_t;

struct astruct
{
    int16_t m;
};

extern void g ( struct astruct *p );
int16_t xyz = 0;

void func ( struct astruct xyz )  /* Non-compliant */
{
    g ( &xyz );
}
```

In this example, the parameter `xyz` of function `func` hides the global variable `xyz`.

It is not immediately clear to a reader which `xyz` is referred to in the statement `g (&xyz )`.

Check Information

Group: Identifiers
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 5.2|MISRA C:2012 Rule 5.8`

Introduced in R2014b

MISRA C:2012 Rule 5.4

Macro identifiers shall be distinct

Description

Rule Definition

Macro identifiers shall be distinct.

Rationale

The names of macro identifiers must be distinct from both other macro identifiers and their parameters.

Polyspace considers two names as distinct if there is a difference between their first 63 characters. If the difference between two names occurs only beyond the first 63 characters, they can be easily mistaken for each other. The readability of the code is reduced. For C90, the difference must occur between the first 31 characters. To use the C90 rules checking, use the value `c90` for the option .

Message in Report

- Macro identifiers shall be distinct. Macro XX has same significant characters as macro YY.
- Macro identifiers shall be distinct. Macro parameter XX has same significant characters as macro parameter YY in macro ZZ.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

C90: First 31 Characters of Macro Names Not Unique

```
#define engine_exhaust_gas_temperature_raw egt_r
#define engine_exhaust_gas_temperature_scaled egt_s   /* Non-compliant */

#define engine_exhaust_gas_temp_raw egt_r
#define engine_exhaust_gas_temp_scaled egt_s          /* Compliant */
```

In this example, the macro `engine_exhaust_gas_temperature_scaled egt_s` has the same first 31 characters as a previous macro `engine_exhaust_gas_temperature_scaled`.

C99: First 63 Characters of Macro Names Not Unique

```
#define engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_raw egt_r
#define engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_raw_scaled egt_s
    /* Non-compliant */

/* 63 significant case-sensitive characters in macro identifiers */
#define new_engine_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_raw egt_r
#define new_engine_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_scaled egt_s
    /* Compliant */
```

In this example, the macro `engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx___gaz_scaled` has the same first 63 characters as a previous macro `engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx___raw`.

Check Information

Group: Identifiers
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 5.1|MISRA C:2012 Rule 5.2|MISRA C:2012 Rule 5.5`

Introduced in R2014b

MISRA C:2012 Rule 5.5

Identifiers shall be distinct from macro names

Description

Rule Definition

Identifiers shall be distinct from macro names.

Rationale

The rule requires that macro names that exist only prior to processing must be different from identifier names that also exist after preprocessing. Keeping macro names and identifiers distinct help avoid confusion.

Polyspace considers two names as distinct if there is a difference between their first 63 characters. If the difference between two names occurs only beyond the first 63 characters, they can be easily mistaken for each other. The readability of the code is reduced. For C90, the difference must occur between the first 31 characters. To use the C90 rules checking, use the value `c90` for the option .

Message in Report

Identifier XX has same significant characters as macro YY.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Macro Names Same as Identifier Names

```
#define Sum_1(x, y) ( ( x ) + ( y ) )
short Sum_1;                    /* Non-compliant */

#define Sum_2(x, y) ( ( x ) + ( y ) )
short x = Sum_2 ( 1, 2 );       /* Compliant */
```

In this example, `Sum_1` is both the name of an identifier and a macro. `Sum_2` is used only as a macro.

C90: First 31 Characters of Macro Name Same as Identifier Name

```
#define       low_pressure_turbine_temperature_1 lp_tb_temp_1
static int low_pressure_turbine_temperature_2;      /* Non-compliant  */
```

In this example, the identifier `low_pressure_turbine_temperature_2` has the same first 31 characters as a previous macro `low_pressure_turbine_temperature_1`.

Check Information

Group: Identifiers
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 5.1|MISRA C:2012 Rule 5.2|MISRA C:2012 Rule 5.4`

Introduced in R2014b

MISRA C:2012 Rule 5.6

A typedef name shall be a unique identifier

Description

Rule Definition

A typedef name shall be a unique identifier.

Rationale

Reusing a `typedef` name as another `typedef` or as the name of a function, object or `enum` constant can cause developer confusion.

Message in Report

XX conflicts with the typedef name YY.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

`typedef` Names Reused

```
void func ( void ){
  {
    typedef unsigned char u8_t;
  }
  {
    typedef unsigned char u8_t; /* Non-compliant */
```

```
  }
}

typedef float mass;
void func1 ( void ){
  float mass = 0.0f;            /* Non-compliant */
}
```

In this example, the `typedef` name `u8_t` is used twice. The `typedef` name `mass` is also used as an identifier name.

`typedef` Name Same as Structure Name

```
typedef struct list{          /* Compliant - exception */
  struct list *next;
  unsigned short element;
} list;

typedef struct{
  struct chain{               /* Non-compliant */
    struct chain *list2;
    unsigned short element;
  } s1;
  unsigned short length;
} chain;
```

In this example, the `typedef` name `list` is the same as the original name of the `struct` type. The rule allows this exceptional case.

However, the `typedef` name `chain` is not the same as the original name of the `struct` type. The name `chain` is associated with a different `struct` type. Therefore, it clashes with the `typedef` name.

Check Information

Group: Identifiers
Category:
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Rule 5.7

Introduced in R2014b

MISRA C:2012 Rule 5.7

A tag name shall be a unique identifier

Description

Rule Definition

A tag name shall be a unique identifier.

Rationale

Reusing a tag name can cause developer confusion.

Message in Report

XX conflicts with the tag name YY.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Identifiers
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 5.6`

Introduced in R2014b

MISRA C:2012 Rule 5.8

Identifiers that define objects or functions with external linkage shall be unique

Description

Rule Definition

Identifiers that define objects or functions with external linkage shall be unique.

Rationale

External identifiers are those declared with global scope or with storage class `extern`. Reusing an external identifier name can cause developer confusion.

Identifiers defined within a function have smaller scope. Even if names of such identifiers are not unique, they are not likely to cause confusion.

Message in Report

- Object XX conflicts with the object name YY.
- Function XX conflicts with the function name YY.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Identifiers
Category: Required
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Rule 5.3

Introduced in R2014b

MISRA C:2012 Rule 5.9

Identifiers that define objects or functions with internal linkage should be unique

Description

Rule Definition

Identifiers that define objects or functions with internal linkage should be unique.

Polyspace Implementation

This rule checker assumes that rule 5.8 is not violated.

Message in Report

- Object XX conflicts with the object name YY.
- Function XX conflicts with the function name YY.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Identifiers
Category: Advisory
AGC Category: Readability
Language: C90, C99

See Also

`MISRA C:2012 Rule 8.10`

Introduced in R2014b

MISRA C:2012 Rule 6.1

Bit-fields shall only be declared with an appropriate type

Description

Rule Definition

Bit-fields shall only be declared with an appropriate type.

Rationale

Using `int` is implementation-defined because bit-fields of type `int` can be either `signed` or `unsigned`.

The use of `enum`, `short char`, or any other type of bit-field is not permitted in C90 because the behavior is undefined.

In C99, the implementation can potentially define other integer types that are permitted in bit-field declarations.

Message in Report

Bit-fields shall only be declared with an appropriate type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Types
Category: Required
AGC Category: Required

Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 6.2

Single-bit named bit fields shall not be of a signed type

Description

Rule Definition

Single-bit named bit fields shall not be of a signed type.

Rationale

According to the C99 Standard Section 6.2.6.2, a single-bit signed bit-field has one sign bit and no value bits. In any representation of integers, zero value bits cannot specify a meaningful value.

A single-bit signed bit-field is therefore unlikely to behave in a useful way. Its presence is likely to indicate programmer confusion.

Although the C90 Standard does not provide much detail regarding the representation of types, the same single-bit bit-field considerations apply.

Polyspace Implementation

This rule does not apply to unnamed bit fields because their values cannot be accessed.

Message in Report

Single-bit named bit fields shall not be of a signed type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Types
Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 7.1

Octal constants shall not be used

Description

Rule Definition

Octal constants shall not be used.

Rationale

Octal constants are denoted by a leading zero. Developers can mistake an octal constant as a decimal constant with a redundant leading zero.

Polyspace Implementation

If you use octal constants in a macro definition, the rule checker flags the issue even if the macro is not used.

Message in Report

Octal constants shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Use of octal constants

```
#define CST     021
#define VALUE   010             /* Compliant - constant not used */
```

```
#if 010 == 01                    /* Non-Compliant - constant used */
#define CST 021                  /* Non-Compliant - constant not used */
#endif

extern short code[5];
static char* str2 = "abcd\0efg";  /* Compliant */

void main(void) {
    int value1 = 0;               /* Compliant */
    int value2 = 01;              /* Non-Compliant - decimal 01 */
    int value3 = 1;               /* Compliant */
    int value4 = '\109';          /* Compliant */

    code[1] = 109;                /* Compliant     - decimal 109 */
    code[2] = 100;                /* Compliant     - decimal 100 */
    code[3] = 052;                /* Non-Compliant - decimal 42 */
    code[4] = 071;                /* Non-Compliant - decimal 57 */

    if (value1 != CST) {          /* Non-Compliant - decimal 17 */
        value1 = !(value1 != 0);  /* Compliant */
    }
}
```

In this example, the rule is not violated when octal constants are used to define macros `CST` and `VALUE`. The rule is violated only when the macros are used.

Check Information

Group: Literals and Constants
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 7.2

A “u” or “U” suffix shall be applied to all integer constants that are represented in an unsigned type

Description

Rule Definition

A “u” or “U” suffix shall be applied to all integer constants that are represented in an unsigned type.

Rationale

The signedness of a constant is determined from:

- Value of the constant.
- Base of the constant: octal, decimal or hexadecimal.
- Size of the various types.
- Any suffixes used.

Unless you use a suffix `u` or `U`, another developer looking at your code cannot determine easily whether a constant is signed or unsigned.

Message in Report

A “u” or “U” suffix shall be applied to all integer constants that are represented in an unsigned type.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Literals and Constants
Category: Required
AGC Category: Readability
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 7.3

The lowercase character “l” shall not be used in a literal suffix

Description

Rule Definition

The lowercase character “l” shall not be used in a literal suffix.

Rationale

The lowercase character “l” can be confused with the digit “1”. Use the uppercase “L” instead.

Message in Report

The lowercase character “l” shall not be used in a literal suffix.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Literals and Constants
Category: Required
AGC Category: Readability
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 7.4

A string literal shall not be assigned to an object unless the object's type is "pointer to const-qualified char"

Description

Rule Definition

A string literal shall not be assigned to an object unless the object's type is "pointer to const-qualified char".

Rationale

This rule prevents assignments that allow modification of a string literal.

An attempt to modify a string literal can result in undefined behavior. For example, some implementations can store string literals in read-only memory. An attempt to modify the string literal can result in an exception or crash.

Message in Report

A string literal shall not be assigned to an object unless the object's type is "pointer to const-qualified char".

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Incorrect Assignment of String Literal

```
char *str1 = "AccountHolderName";
const char *str2 = "AccountHolderName";

void checkAccount1(char*);              /* Non-Compliant */
void checkAccount2(const char*);        /* Compliant */

void main() {
 checkAccount1("AccountHolderName");    /* Non-Compliant */
 checkAccount2("AccountHolderName");    /* Compliant */
}
```

In this example, the rule is not violated when string literals are assigned to `const char*` pointers, either directly or through copy of function arguments. The rule is violated only when the `const` qualifier is not used.

Check Information

Group: Literals and Constants
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 11.4|MISRA C:2012 Rule 11.8`

Introduced in R2014b

MISRA C:2012 Rule 8.1

Types shall be explicitly specified

Description

Rule Definition

Types shall be explicitly specified.

Rationale

In some circumstances, you can omit types from the C90 standard. In those cases, the `int` type is implicitly specified. However, the omission of an explicit type can lead to confusion. For example, in the declaration `extern void foo (char c, const k);`, the type of `k` is `const int`, but you might expect `const char`.

You might be using an implicit type in:

- Object declarations
- Parameter declarations
- Member declarations
- `typedef` declarations
- Function return types

Polyspace Implementation

The rule checker flags situations where a function parameter or return type is not explicitly specified. To enable checking of this rule, use the value `c90` for the option `C standard version (-c-version)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Message in Report

Types shall be explicitly specified.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Implicit Types

```
static foo(int a);  /* Non compliant */
static void bar(void);      /* Compliant */
```

In this example, the rule is violated because the return type of `foo` is implicit.

Check Information

Group: Declarations and Definitions
Category: Required
AGC Category: Required
Language: C90

See Also

`MISRA C:2012 Rule 8.2`

Introduced in R2014b

MISRA C:2012 Rule 8.10

An inline function shall be declared with the static storage class

Description

Rule Definition

An inline function shall be declared with the static storage class.

Rationale

If you call an inline function that is declared with external linkage but not defined in the same translation unit, the function might not be inlined. You might not see the reduction in execution time that you expect from inlining.

If you want to make an inline function available to several translation units, you can still define it with the `static` specifier. In this case, place the definition in a header file. Include the header file in all the files where you want the function inlined.

Polyspace Implementation

The rule checker flags definitions that contain the `inline` specifier without an accompanying `static` specifier.

Message in Report

An inline function shall be declared with the static storage class.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Inlining Functions with External Linkage

```
inline double mult(int val);
inline double mult(int val) {   /* Non compliant */
    return val * 2.0;
}

static inline double div(int val);
static inline double div(int val) {  /* Compliant */
    return val / 2.0;
}
```

In this example, the definition of `mult` is noncompliant because it is inlined without the `static` storage specifier.

Check Information

Group: Declarations and Definitions
Category: Required
AGC Category: Required
Language: C99

See Also

`MISRA C:2012 Rule 5.9`

Introduced in R2014b

MISRA C:2012 Rule 8.11

When an array with external linkage is declared, its size should be explicitly specified

Description

Rule Definition

When an array with external linkage is declared, its size should be explicitly specified.

Rationale

Although it is possible to declare an array with an incomplete type and access its elements, it is safer to state the size of the array explicitly. If you provide size information for each declaration, a code reviewer can check multiple declarations for their consistency. With size information, a static analysis tool can perform array bounds analysis without analyzing more than one unit.

Polyspace Implementation

The rule checker flags arrays declared with the `extern` specifier if the declaration does not explicitly specify the array size.

Message in Report

Size of array *`array_name`* should be explicitly stated. When an array with external linkage is declared, its size should be explicitly specified.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Array Declarations

```
extern int32_t array1[10];    /*  Compliant  */
extern int32_t array2[];      /*  Non-compliant  */
```

In this example, two arrays are declared `array1` and `array2`. `array1` has external linkage (the `extern` keyword) and a size of 10. `array2` also has external linkage, but no specified size. `array2` is noncompliant because for arrays with external linkage, you must explicitly specify a size.

Check Information

Group: Declarations and Definitions
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 8.12

Within an enumerator list, the value of an implicitly-specified enumeration constant shall be unique

Description

Rule Definition

Within an enumerator list, the value of an implicitly-specified enumeration constant shall be unique.

Rationale

An implicitly specified enumeration constant has a value one greater than its predecessor. If the first enumeration constant is implicitly specified, then its value is 0. An explicitly specified enumeration constant has the specified value.

If implicitly and explicitly specified constants are mixed within an enumeration list, it is possible for your program to replicate values. Such replications can be unintentional and can cause unexpected behavior.

Polyspace Implementation

The rule checker flags an enumeration if it has an implicitly specified enumeration constant with the same value as another enumeration constant.

Message in Report

The constant *`constant1`* has same value as the constant *`constant2`*.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Replication of Value in Implicitly Specified Enum Constants

```
enum color1 {red_1, blue_1, green_1};   /* Compliant */
enum color2 {red_2 = 1, blue_2 = 2, green_2 = 3};       /* Compliant */
enum color3 {red_3 = 1, blue_3, green_3};     /* Compliant */
enum color4 {red_4, blue_4, green_4 = 1};     /* Non Compliant */
enum color5 {red_5 = 2, blue_5, green_5 = 2};     /* Compliant */
enum color6 {red_6 = 2, blue_6, green_6 = 2, yellow_6};     /* Non Compliant */
```

Compliant situations:

- `color1`: All constants are implicitly specified.
- `color2`: All constants are explicitly specified.
- `color3`: Though there is a mix of implicit and explicit specification, all constants have unique values.
- `color5`: The implicitly specified constants have unique values.

Noncompliant situations:

- `color4`: The implicitly specified constant `blue_4` has the same value as `green_4`.
- `color6`: The implicitly specified constant `blue_6` has the same value as `yellow_6`.

Check Information

Group: Declarations and Definitions
Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 8.13

A pointer should point to a const-qualified type whenever possible

Description

Rule Definition

A pointer should point to a const-qualified type whenever possible.

Rationale

This rule ensures that you do not inadvertently use pointers to modify objects.

Polyspace Implementation

The rule checker flags a pointer to a non-`const` function parameter if the pointer does not modify the addressed object. The assumption is that the pointer is not meant to modify the object and so must point to a `const`-qualified type.

Message in Report

A pointer should point to a const-qualified type whenever possible.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Pointer That Should Point to `const`-Qualified Types

```
#include <string.h>
```

```
typedef unsigned short uint16_t;

uint16_t ptr_ex(uint16_t *p) {      /* Non-compliant */
    return *p;
}

char last_char(char * const s){     /* Non-compliant */
    return s[strlen(s) - 1u];
}

uint16_t first(uint16_t a[5]){      /* Non-compliant */
    return a[0];
}
```

This example shows three different noncompliant pointer parameters.

- In the `ptr_ex` function, `p` does not modify an object. However, the type to which `p` points is not `const`-qualified, so it is noncompliant.
- In `last_char`, the pointer `s` is `const`-qualified but the type it points to is not. This parameter is noncompliant because `s` does not modify an object.
- The function `first` does not modify the elements of the array `a`. However, the element type is not `const`-qualified, so `a` is also noncompliant.

Correction — Use `const` Keywords

One possible correction is to add `const` qualifiers to the definitions.

```
#include <string.h>

typedef unsigned short uint16_t;

uint16_t ptr_ex(const uint16_t *p){     /* Compliant */
    return *p;
}

char last_char(const char * const s){   /* Compliant */
    return s[strlen( s ) - 1u];
}

uint16_t first(const uint16_t a[5]) {   /* Compliant */
    return a[0];
}
```

Check Information

Group: Declarations and Definitions
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 8.14

The restrict type qualifier shall not be used

Description

Rule Definition

The restrict type qualifier shall not be used.

Rationale

When you use a `restrict` qualifier carefully, it improves the efficiency of code generated by a compiler. It can also improve static analysis. However, when using the `restrict` qualifier, it is difficult to make sure that the memory areas operated on by two or more pointers do not overlap.

Polyspace Implementation

The rule checker flags all uses of the `restrict` qualifier.

Message in Report

The restrict type qualifier shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Use of `restrict` Qualifier

```
void f(int n, int * restrict p, int * restrict q)
{
}
```

In this example, both uses of the `restrict` qualifier are flagged.

Check Information

Group: Declarations and Definitions
Category: Required
AGC Category: Advisory
Language: C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 8.2

Function types shall be in prototype form with named parameters

Description

Rule Definition

Function types shall be in prototype form with named parameters.

Rationale

The rule requires that you specify names and data types for all the parameters in a declaration. The parameter names provide useful information regarding the function interface. A mismatch between a declaration and definition can indicate a programming error. For instance, you mixed up parameters when defining the function. By insisting on parameter names, the rule allows a code reviewer to detect this mismatch.

Polyspace Implementation

The rule checker shows a violation if the parameters in a function declaration or definition are missing names or data types.

Message in Report

- Too many arguments to *`function_name`*.
- Too few arguments to *`function_name`*.
- Function types shall be in prototype form with named parameters.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Function Prototype Without Named Parameters

```
extern int func(int);   /* Non compliant */
extern int func2(int n);   /* Compliant */

extern int func3();   /* Non compliant */
extern int func4(void);   /* Compliant */
```

In this example, the declarations of `func` and `func3` are noncompliant because the parameters are missing or do not have names.

Check Information

Group: Declarations and Definitions
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Rule 8.1|MISRA C:2012 Rule 8.4|MISRA C:2012 Rule 17.3`

Introduced in R2014b

MISRA C:2012 Rule 8.3

All declarations of an object or function shall use the same names and type qualifiers

Description

Rule Definition

All declarations of an object or function shall use the same names and type qualifiers.

Rationale

Consistently using parameter names and types across declarations of the same object or function encourages stronger typing. It is easier to check that the same function interface is used across all declarations.

Polyspace Implementation

The rule checker detects situations where parameter names or data types are different between multiple declarations or the declaration and the definition. The checker considers declarations in all translation units and flags issues that are not likely to be detected by a compiler.

Polyspace Bug Finder and Polyspace Code Prover check this coding rule differently. The analyses can produce different results.

Message in Report

- Definition of function *`function_name`* incompatible with its declaration.
- Global declaration of *`function_name`* function has incompatible type with its definition.
- Global declaration of *`variable_name`* variable has incompatible type with its definition.
- All declarations of an object or function shall use the same names and type qualifiers.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Mismatch in Parameter Names

```
extern int div (int num, int den);

int div(int den, int num) { /* Non compliant */
    return(num/den);
}
```

In this example, the rule is violated because the parameter names in the declaration and definition are switched.

Mismatch in Parameter Data Types

```
typedef unsigned short width;
typedef unsigned short height;
typedef unsigned int area;

extern area calculate(width w, height h);

area calculate(width w, width h) { /* Non compliant *
    return w*h;
}
```

In this example, the rule is violated because the second argument of the `calculate` function has data type:

- `height` in the declaration.
- `width` in the definition.

The rule is violated even though the underlying type of `height` and `width` are identical.

Check Information

Group: Declarations and Definitions
Category: Required
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Rule 8.4

Introduced in R2014b

MISRA C:2012 Rule 8.4

A compatible declaration shall be visible when an object or function with external linkage is defined

Description

Rule Definition

A compatible declaration shall be visible when an object or function with external linkage is defined.

Rationale

If a declaration is visible when an object or function is defined, it allows the compiler to check that the declaration and the definition are compatible.

This rule with `MISRA C:2012 Rule 8.5` enforces the practice of declaring an object (or function) in a header file and including the header file in source files that define or use the object (or function).

Polyspace Implementation

The rule checker detects situations where:

- An object or function is defined without a previous declaration.
- There is a data type mismatch between the object or function declaration and definition. Such a mismatch also causes a compilation error.

Message in Report

- Global definition of *`variable_name`* variable has no previous declaration.
- Function *`function_name`* has no visible compatible prototype at definition.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Definition Without Previous Declaration

Header file:

```
/* file.h */
extern int var2;
void func2(void);
```

Source file:

```
/* file.c */
#include "file.h"

int var1 = 0;    /* Non compliant */
int var2 = 0;    /* Compliant */

void func1(void) {   /* Non compliant */
}

void func2(void) {   /* Compliant */
}
```

In this example, the definitions of `var1` and `func1` are noncompliant because they are not preceded by declarations.

Mismatch in Parameter Data Types

```
void func(int param1, int param2);

void func(int param1, unsigned int param2) { /* Non compliant */
}
```

In this example, the definition of `func` has a different parameter type from its declaration. The mismatch also causes a compilation error.

Check Information

Group: Declarations and Definitions
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 8.2|MISRA C:2012 Rule 8.3|MISRA C:2012 Rule 8.5|MISRA C:2012 Rule 17.3

Introduced in R2014b

MISRA C:2012 Rule 8.5

An external object or function shall be declared once in one and only one file

Description

Rule Definition

An external object or function shall be declared once in one and only one file.

Rationale

If you declare an identifier in a header file, you can include the header file in any translation unit where the identifier is defined or used. In this way, you ensure consistency between:

- The declaration and the definition.
- The declarations in different translation units.

The rule enforces the practice of declaring external objects or functions in header files.

Polyspace Implementation

The rule checker checks only explicit `extern` declarations (tentative definitions are ignored). The checker flags variables or functions declared `extern` in a non-header file.

Polyspace Bug Finder and Polyspace Code Prover check this coding rule differently. The analyses can produce different results.

Message in Report

- Object *`object_name`* has external declarations in multiple files.
- Function *`function_name`* has external declarations in multiple files.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Extern Declaration in Non-Header File

Header file:

```
/* file.h */
extern int var;
extern void func1(void);   /* Compliant */
```

Source file:

```
/* file.c */
#include "file.h"

extern void func2(void);   /* Non compliant */

/* Definitions */
int var = 0;
void func1(void) {}
```

In this example, the declaration of external function `func2` is noncompliant because it occurs in a non-header file. The other external object and function declarations occur in a header file and comply with this rule.

Check Information

Group: Declarations and Definitions
Category: Required
AGC Category: Advisory
Language: C90, C99

See Also

`MISRA C:2012 Rule 8.4`

Introduced in R2014b

MISRA C:2012 Rule 8.6

An identifier with external linkage shall have exactly one external definition

Description

Rule Definition

An identifier with external linkage shall have exactly one external definition.

Rationale

If you use an identifier for which multiple definitions exist in different files or no definition exists, the behavior is undefined.

Multiple definitions in different files are not permitted by this rule even if the definitions are the same.

Polyspace Implementation

The checker flags multiple definitions only if the definitions occur in different files.

The checker does not consider tentative definitions as definitions. For instance, the following code does not violate the rule:

```
int val;
int val=1;
```

The checker does not show a violation if a function is not defined at all but declared with external linkage and called in the source code.

Polyspace Bug Finder and Polyspace Code Prover check this coding rule differently. The analyses can produce different results.

Message in Report

- Forbidden multiple definitions for function *`function_name`*.
- Forbidden multiple tentative definitions for object *`object_name`*.
- Global variable *`variable_name`* multiply defined.
- Function *`function_name`* multiply defined.
- Global variable has multiple tentative definitions.
- Undefined global variable *`variable_name`*.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Variable Multiply Defined

First source file:

```
extern int var = 1;
```

Second source file:

```
int var = 0;   /* Non compliant */
```

In this example, the global variable `var` is multiply defined. Unless explicitly specified with the `static` qualifier, the variables have external linkage.

Function Multiply Defined

Header file:

```
/* file.h */
int func(int param);
```

First source file:

```
/* file1.c */
#include "file.h"

int func(int param) {
    return param+1;
}
```

Second source file:

```
/* file2.c */
#include "file.h"

int func(int param) {  /* Non compliant */
    return param-1;
}
```

In this example, the function `func` is multiply defined. Unless explicitly specified with the `static` qualifier, the functions have external linkage.

Check Information

Group: Declarations and Definitions
Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 8.7

Functions and objects should not be defined with external linkage if they are referenced in only one translation unit

Description

Rule Definition

Functions and objects should not be defined with external linkage if they are referenced in only one translation unit.

Rationale

Compliance with this rule avoids confusion between your identifier and an identical identifier in another translation unit or library. If you restrict or reduce the visibility of an object by giving it internal linkage or no linkage, you or someone else is less likely to access the object inadvertently.

Polyspace Implementation

The rule checker flags:

- Objects that are defined at file scope without the `static` specifier but used only in one file.
- Functions that are defined without the `static` specifier but called only in one file.

If you intend to use the object or function in one file only, declare it static.

Polyspace Bug Finder and Polyspace Code Prover check this coding rule differently. The analyses can produce different results.

Message in Report

- Variable *`variable_name`* should have internal linkage.

- Function *`function_name`* should have internal linkage.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Variable with External Linkage Used in One File

Header file:

```
/* file.h */
extern int var;
```

First source file:

```
/* file1.c */
#include "file.h"

int var;    /* Compliant */
int var2;   /* Non compliant */
static int var3; /* Compliant */

void reset(void);

void reset(void) {
    var = 0;
    var2 = 0;
    var3 = 0;
}
```

Second source file:

```
/* file2.c */
#include "file.h"

void increment(int var2);

void increment(int var2) {
```

```
    var++;
    var2++;
}
```

In this example:

- The declaration of `var` is compliant because `var` is declared with external linkage and used in multiple files.
- The declaration of `var2` is noncompliant because `var2` is declared with external linkage but used in one file only.

  It might appear that `var2` is defined in both files. However, in the second file, `var2` is a parameter with no linkage and is not the same as the `var2` in the first file.
- The declaration of `var3` is compliant because `var3` is declared with internal linkage (with the `static` specifier) and used in one file only.

Function with External Linkage Used in One File

Header file:

```
/* file.h */
extern int var;
extern void increment1 (void);
```

First source file:

```
/* file1.c */
#include "file.h"

int var;

void increment2(void);
static void increment3(void);
void func(void);

void increment2(void) { /* Non compliant */
    var+=2;
}

static void increment3(void) { /* Compliant */
    var+=3;
}
```

```
void func(void) {
    increment1();
    increment2();
    increment3();
}
```

Second source file:

```
/* file2.c */
#include "file.h"

void increment1(void) { /* Compliant */
    var++;
}
```

In this example:

- The definition of `increment1` is compliant because `increment1` is defined with external linkage and called in a different file.
- The declaration of `increment2` is noncompliant because `increment2` is defined with external linkage but called in the same file and nowhere else.
- The declaration of `increment3` is compliant because `increment3` is defined with internal linkage (with the `static` specifier) and called in the same file and nowhere else.

Check Information

Group: Declarations and Definitions
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 8.8

The static storage class specifier shall be used in all declarations of objects and functions that have internal linkage

Description

Rule Definition

The static storage class specifier shall be used in all declarations of objects and functions that have internal linkage.

Rationale

If you do not use the `static` specifier consistently in all declarations of objects with internal linkage, you might declare the same object with external and internal linkage.

In this situation, the linkage follows the earlier specification that is visible (C99 Standard, Section 6.2.2). For instance, if the earlier specification indicates internal linkage, the object has internal linkage even though the latter specification indicates external linkage. If you notice the latter specification alone, you might expect otherwise.

Polyspace Implementation

The rule checker detects situations where:

- The same object is declared multiple times with different storage specifiers.
- The same function is declared and defined with different storage specifiers.

Message in Report

The static storage class specifier shall be used in all declarations of objects and functions that have internal linkage.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Linkage Conflict Between Variable Declarations

```
static int foo = 0;
extern int foo;         /* Non-compliant */

extern int hhh;
static int hhh;         /* Non-compliant */
```

In this example, the first line defines `foo` with internal linkage. The first line is compliant because the example uses the `static` keyword. The second line does not use `static` in the declaration, so the declaration is noncompliant. By comparison, the third line declares `hhh` with an `extern` keyword creating external linkage. The fourth line declares `hhh` with internal linkage, but this declaration conflicts with the first declaration of `hhh`.

Correction — Consistent `static` and `extern` Use

One possible correction is to use `static` and `extern` consistently:

```
static int foo = 0;
static int foo;

extern int hhh;
extern int hhh;
```

Linkage Conflict Between Function Declaration and Definition

```
static int fee(void);  /* Compliant - declaration: internal linkage */
int fee(void){         /* Non-compliant */
  return 1;
}

static int ggg(void);  /* Compliant - declaration: internal linkage */
extern int ggg(void){  /* Non-compliant */
```

```
  return 1 + x;
}
```

This example shows two internal linkage violations. Because `fee` and `ggg` have internal linkage, you must use a `static` class specifier to be compliant with MISRA.

Check Information

Group: Declarations and Definitions
Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 8.9

An object should be defined at block scope if its identifier only appears in a single function

Description

Rule Definition

An object should be defined at block scope if its identifier only appears in a single function.

Rationale

If you define an object at block scope, you or someone else is less likely to access the object inadvertently outside the block.

Polyspace Implementation

The rule checker flags `static` objects that are accessed in one function only but declared at file scope.

Message in Report

An object should be defined at block scope if its identifier only appears in a single function.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Object Declared at File Scope but Used in One Function

```
static int ctr;   /* Non compliant */

int checkStatus(void);
void incrementCount(void);

void incrementCount(void) {
    ctr=0;
    while(1) {
        if(checkStatus())
            ctr++;
    }
}
```

In this example, the declaration of `ctr` is noncompliant because it is declared at file scope but used only in the function `incrementCount`. Declare `ctr` in the body of `incrementCount` to be MISRA C-compliant.

Check Information

Group: Declarations and Definitions
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 9.1

The value of an object with automatic storage duration shall not be read before it has been set

Description

Message in Report:

Rule Definition

The value of an object with automatic storage duration shall not be read before it has been set.

Rationale

A variable with an automatic storage duration is allocated memory at the beginning of an enclosing code block and deallocated at the end. All non-global variables have this storage duration, except those declared `static` or `extern`.

Variables with automatic storage duration are not automatically initialized and have indeterminate values. Therefore, you must not read such a variable before you have set its value through a write operation.

Polyspace Implementation

The Polyspace analysis checks some of the violations as non-initialized variables. For more information, see `Non-initialized variable`.

Polyspace Bug Finder and Polyspace Code Prover check this coding rule differently. The analyses can produce different results. In Code Prover, you can also see a difference in results based on your choice for the option `Verification level (-to)`. . For more information on analysis options, see the documentation for Polyspace Code Prover or Polyspace Code Prover Server.

Message in Report

The value of an object with automatic storage duration shall not be read before it has been set.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Initialization
Category: Mandatory
AGC Category: Mandatory
Language: C90, C99

See Also

`MISRA C:2012 Rule 15.1|MISRA C:2012 Rule 15.3`

Introduced in R2014b

MISRA C:2012 Rule 9.2

The initializer for an aggregate or union shall be enclosed in braces

Description

Rule Definition

The initializer for an aggregate or union shall be enclosed in braces.

Rationale

The rule applies to both objects and subobjects. For example, when initializing a structure that contains an array, the values assigned to the structure must be enclosed in braces. Within these braces, the values assigned to the array must be enclosed in another pair of braces.

Enclosing initializers in braces improves clarity of code that contains complex data structures such as multidimensional arrays and arrays of structures.

Tip To avoid nested braces for subobjects, use the syntax `{0}`, which sets all values to zero.

Message in Report

The initializer for an aggregate or union shall be enclosed in braces.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Initialization of Two-dimensional Arrays

```
void initialize(void) {
    int x[4][2] = {{0,0},{1,0},{0,1},{1,1}}; /* Compliant */
    int y[4][2] = {{0},{1,0},{0,1},{1,1}};   /* Compliant */
    int z[4][2] = {0};                       /* Compliant */
    int w[4][2] = {0,0,1,0,0,1,1,1};         /* Non-compliant */
}
```

In this example, the rule is not violated when:

- Initializers for each row of the array are enclosed in braces.
- The syntax `{0}` initializes all elements to zero.

The rule is violated when a separate pair of braces is not used to enclose the initializers for each row.

Check Information

Group: Initialization
Category: Required
AGC Category: Readability
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 9.3

Arrays shall not be partially initialized

Description

Rule Definition

Arrays shall not be partially initialized.

Rationale

Providing an explicit initialization for each array element makes it clear that every element has been considered.

Message in Report

Arrays shall not be partially initialized.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Partial and Complete Initializations

```
void func(void) {
    int x[3] = {0,1,2};              /* Compliant */
    int y[3] = {0,1};                /* Non-compliant */
    int z[3] = {0};                  /* Compliant - exception */
    int a[30] = {[1] = 1,[15]=1};    /* Compliant - exception */
    int b[30] = {{1} = 1, 1};        /* Non-compliant */
```

```
    char c[20] = "Hello World";       /* Compliant - exception */
}
```

In this example, the rule is not violated when each array element is explicitly initialized.

The rule is violated when some elements of the array are implicitly initialized. Exceptions include the following:

- The initializer has the form `{0}`, which initializes all elements to zero.
- The array initializer consists *only* of designated initializers. Typically, you use this approach for sparse initialization.
- The array is initialized using a string literal.

Check Information

Group: Initialization
Category: Required
AGC Category: Readability
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 9.4

An element of an object shall not be initialized more than once

Description

Rule Definition

An element of an object shall not be initialized more than once.

Rationale

Designated initializers allow explicitly initializing elements of objects such as arrays in any order. However, using designated initializers, one can inadvertently initialize the same element twice and therefore overwrite the first initialization.

Message in Report

An element of an object shall not be initialized more than once.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Array Initialization Using Designated Initializers

```
void func(void) {
    int a[5] = {-2,-1,0,1,2};               /* Compliant */
    int b[5] = {[0]=-2, [1]=-1, [2]=0, [3]=1, [4]=2};
                                            /* Compliant */
    int c[5] = {[0]=-2, [1]=-1, [1]=0, [3]=1, [4]=2};
```

```
                                                /* Non-compliant */
}
```

In this example, the rule is violated when the array element `c[1]` is initialized twice using a designated initializer.

Structure Initialization Using Designated Initializers

```
struct myStruct {
    int a;
    int b;
    int c;
    int d;
};

void func(void) {
    struct myStruct struct1 = {-4,-2,2,4};   /* Compliant */
    struct myStruct struct2 = {.a=-4, .b=-2, .c=2, .d=4};
                                             /* Compliant */
    struct myStruct struct3 = {.a=-4, .b=-2, .b=2, .d=4};
                                             /* Non-compliant */
}
```

In this example, the rule is violated when `struct3.b` is initialized twice using a designated initializer.

Check Information

Group: Initialization
Category: Required
AGC Category: Required
Language: C99

See Also

Introduced in R2014b

MISRA C:2012 Rule 9.5

Where designated initializers are used to initialize an array object the size of the array shall be specified explicitly

Description

Rule Definition

Where designated initializers are used to initialize an array object the size of the array shall be specified explicitly.

Rationale

If the size of an array is not specified explicitly, it is determined by the highest index of the elements that are initialized. When using long designated initializers, it might not be immediately apparent which element has the highest index.

Message in Report

Where designated initializers are used to initialize an array object the size of the array shall be specified explicitly.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Using Designated Initializers Without Specifying Array Size

```
int a[5] = {[0]= 1, [2] = 1, [4]= 1, [1] = 1};        /* Compliant */
int b[] = {[0]= 1, [2] = 1, [4]= 1, [1] = 1};         /* Non-compliant */
```

```
int c[] = {[0]= 1, [1] = 1, [2]= 1, [3]=0, [4] = 1};  /* Non-compliant */

void display(int);

void main() {
    func(a,5);
    func(b,5);
    func(c,5);
}

void func(int* arr, int size) {
    for(int i=0; i<size; i++)
        display(arr[i]);
}
```

In this example, the rule is violated when the arrays `b` and `c` are initialized using designated initializers but the array size is not specified.

Check Information

Group: Initialization
Category: Required
AGC Category: Readability
Language: C99

See Also

Introduced in R2014b

MISRA C:2012 Dir 1.1

Any implementation-defined behavior on which the output of the program depends shall be documented and understood

Description

Directive Definition

Any implementation-defined behavior on which the output of the program depends shall be documented and understood.

Rationale

A code construct has implementation-defined behavior if the C standard allows compilers to choose their own specifications for the construct. The full list of implementation-defined behavior is available in Annex J.3 of the standard ISO/IEC 9899:1999 (C99) and in Annex G.3 of the standard ISO/IEC 9899:1990 (C90).

If you understand and document all implementation-defined behavior, you can be assured that all output of your program is intentional and not produced by chance.

Polyspace Implementation

The analysis detects the following possibilities of implementation-defined behavior in C99 and their counterparts in C90. If you know the behavior of your compiler implementation, justify the analysis result with appropriate comments. To justify a result, assign one of these statuses: `Justified`, `No action planned`, or `Not a defect`.

Tip To mass-justify all results that indicate the same implementation-defined behavior, use the **Detail** column on the **Results List** pane. Click the column header so that all results with the same entry are grouped together. Select the first result and then select the last result while holding the `Shift` key. Assign a status to one of the results. If you do not see the **Detail** column, right-click any other column header and enable this column.

C99 Standard Annex Ref	Behavior to Be Documented	How Polyspace Helps

J.3.2: Environment	An alternative manner in which `main` function may be defined.	The analysis flags `main` with arguments and return types other than:
		`int main(void) { ... }`
		or
		`int main(int argc, char *argv[]) { ... }`
		See section 5.1.2.2.1 of the C99 Standard.

J.3.2: Environment	The set of environment names and the method for altering the environment list used by the `getenv` function.	The analysis flags uses of the `getenv` function. For this function, you need to know the list of environment variables and how the list is modified. See section 7.20.4.5 of the C99 Standard.
J.3.6: Floating Point	The rounding behaviors characterized by non-standard values of `FLT_ROUNDS`.	The analysis flags the include of `float.h` if values of `FLT_ROUNDS` are outside the set, {-1, 0, 1, 2, 3}. Only the values in this set lead to well-defined rounding behavior. See section 5.2.4.2.2 of the C99 Standard.
J.3.6: Floating Point	The evaluation methods characterized by non-standard negative values of `FLT_EVAL_METHOD`.	The analysis flags the include of `float.h` if values of `FLT_EVAL_METHOD` are outside the set, {-1, 0, 1, 2}. Only the values in this set lead to well-defined behavior for floating-point operations. See section 5.2.4.2.2 of the C99 Standard.

C99 Standard Annex Ref	Behavior to Be Documented	How Polyspace Helps
J.3.6: Floating Point	The direction of rounding when an integer is converted to a floating-point number that cannot exactly represent the original value.	The analysis flags conversions from integer to floating-point data types of smaller size (for example, 64-bit `int` to 32-bit `float`). See section 6.3.1.4 of the C99 Standard.
J.3.6: Floating Point	The direction of rounding when a floating-point number is converted to a narrower floating-point number.	The analysis flags these conversions: • `double` to `float` • `long double` to `double` or `float` See section 6.3.1.5 of the C99 Standard.

J.3.6: Floating Point	The default state for the `FENV_ACCESS` pragma.	The analysis flags use of the pragma other than:
		`#pragma STDC FENV_ACCESS ON`
		or
		`#pragma STDC FENV_ACCESS OFF`
		See section 7.6.1 of the C99 Standard.

J.3.6: Floating Point	The default state for the `FP_CONTRACT` pragma.	The analysis flags use of the pragma other than:
		`#pragma STDC FP_CONTRACT ON`
		or
		`#pragma STDC FP_CONTRACT OFF`
		See section 7.12.2 of the C99 Standard.

C99 Standard Annex Ref	Behavior to Be Documented	How Polyspace Helps
J.3.11: Preprocessing Directives	The behavior on each recognized non-STDC #pragma directive.	The analysis flags the pragma usage: `#pragma` *`pp-tokens`* where the processing token `STDC` does not immediately follow`pragma`. For instance: `#pragma FENV_ACCESS ON` See section 6.10.6 of the C99 Standard.
J.3.12: Library Functions	Whether the `feraiseexcept` function raises the ''inexact'' floating-point exception in addition to the ''overflow'' or ''underflow'' floating-point exception.	The analysis flags calls to the `feraiseexcept` function. See section 7.6.2.3 of the C99 Standard.
J.3.12: Library Functions	Strings other than `"C"` and `""` that may be passed as the second argument to the `setlocale` function.	The analysis flags calls to the `setlocale` function when its second argument is not `"C"` or `""`. See section 7.11.1.1 of the C99 Standard.
J.3.12: Library Functions	The types defined for `float_t` and `double_t` when the value of the `FLT_EVAL_METHOD` macro is less than 0 or greater than 2.	The analysis flags the include of `math.h` if `FLT_EVAL_METHOD` has values outside the set {0,1,2}. See section 7.12 of the C99 Standard.

C99 Standard Annex Ref	Behavior to Be Documented	How Polyspace Helps
J.3.12: Library Functions	The base-2 logarithm of the modulus used by the `remquo` functions in reducing the quotient.	The analysis flags calls to the `remquo`, `remquof` and `remquol` function. See section 7.12.10.3 of the C99 Standard.
J.3.12: Library Functions	The termination status returned to the host environment by the `abort`, `exit`, or `_Exit` function.	The analysis flags calls to the `abort`, `exit`, or `_Exit` function. See sections 7.20.4.1, 7.20.4.3 or 7.20.4.4 of the C99 Standard.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: The implementation
Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2017b

MISRA C:2012 Dir 2.1

All source files shall compile without any compilation errors

Description

Directive Definition

All source files shall compile without any compilation errors.

Rationale

A conforming compiler is permitted to produce an object module despite the presence of compilation errors. However, execution of the resulting program can produce unexpected behavior.

Polyspace Implementation

The software raises a violation of this directive if it finds a compilation error. Because Code Prover is more strict about compilation errors compared to Bug Finder, the coding rules checking in the two products can produce different results for this directive.

Message in Report

All source files shall compile without any compilation errors.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Compilation and build

Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2015b

MISRA C:2012 Dir 4.1

Run-time failures shall be minimized

Description

Directive Definition

Run-time failures shall be minimized.

Rationale

Some areas to concentrate on are:

- Arithmetic errors
- Pointer arithmetic
- Array bound errors
- Function parameters
- Pointer dereferencing
- Dynamic memory

Polyspace Implementation

This directive is checked through the Polyspace analysis. For more information, see:

- “Defects”

Polyspace Bug Finder and Polyspace Code Prover check this coding rule differently. The analyses can produce different results.

Message in Report

Run-time failures shall be minimized.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Code design
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Dir 4.11|MISRA C:2012 Rule 1.3|MISRA C:2012 Rule 18.1|MISRA C:2012 Rule 18.2|MISRA C:2012 Rule 18.3`

Introduced in R2014b

MISRA C:2012 Dir 4.10

Precautions shall be taken in order to prevent the contents of a header file being included more than once

Description

Directive Definition

Precautions shall be taken in order to prevent the contents of a header file being included more than once.

Rationale

When a translation unit contains a complex hierarchy of nested header files, it is possible for a particular header file to be included more than once, leading to confusion. If this multiple inclusion produces multiple or conflicting definitions, then your program can have undefined or erroneous behavior.

For instance, suppose that a header file contains:

```
#ifdef _WIN64
   int env_var;
#elseif
   long int env_var;
#endif
```

If the header file is contained in two inclusion paths, one that defines the macro `_WIN64` and another that undefines it, you can have conflicting definitions of `env_var`.

Polyspace Implementation

If you include a header file whose contents are not guarded from multiple inclusion, the analysis raises a violation of this directive. The violation is shown at the beginning of the header file.

You can guard the contents of a header file from multiple inclusion by using one of the following methods:

```
<start-of-file>
#ifndef <control macro>
#define <control macro>
    /* Contents of file */
#endif
<end-of-file>
```

or

```
<start-of-file>
#ifdef <control macro>
#error ...
#else
#define <control macro>
    /* Contents of file */
#endif
<end-of-file>
```

Unless you use one of these methods, Polyspace flags the header file inclusion as noncompliant.

Message in Report

Precautions shall be taken in order to prevent the contents of a header file being included more than once.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Code After Macro Guard

```
#ifndef  __MY_MACRO__
#define __MY_MACRO__
    void func(void);
```

```
#endif
void func2(void);
```

If a header file contains this code, it is noncompliant because the macro guard does not cover the entire content of the header file. The line `void func2(void)` is outside the guard.

Note You can have comments outside the macro guard.

Code Before Macro Guard

```
void func(void);
#ifndef  __MY_MACRO__
#define __MY_MACRO__
    void func2(void);
#endif
```

If a header file contains this code, it is noncompliant because the macro guard does not cover the entire content of the header file. The line `void func(void)` is outside the guard.

Note You can have comments outside the macro guard.

Mismatch in Macro Guard

```
#ifndef  __MY_MACRO__
#define __MY_MARCO__
    void func(void);
    void func2(void);
#endif
```

If a header file contains this code, it is noncompliant because the macro name in the `#ifndef` statement is different from the name in the following `#define` statement.

Check Information

Group: Code Design

Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Dir 4.11

The validity of values passed to library functions shall be checked

Description

Directive Definition

The validity of values passed to library functions shall be checked.

Rationale

Many Standard C functions do not check the validity of parameters passed to them. Even if checks are performed by a compiler, there is no guarantee that the checks are adequate. For example, you should not pass negative numbers to `sqrt` or `log`.

Polyspace Implementation

Polyspace raises a violation result for library function arguments if the following are all true:

- Argument is a local variable.
- Local variable is not tested between last assignment and call to the library function.
- Corresponding parameter of the library function has a restricted input domain.
- Library function is one of the following common mathematical functions:
  - `sqrt`
  - `tan`
  - `pow`
  - `log`
  - `log10`
  - `fmod`
  - `acos`

- `asin`
- `acosh`
- `atanh`
- or `atan2`

Bug Finder and Code Prover check this rule differently. The analysis can produce different results.

Tip To mass-justify all results related to the same library function, use the **Detail** column on the **Results List** pane. Click the column header so that all results with the same entry are grouped together. Select the first result and then select the last result while holding the `Shift` key. Assign a status to one of the results. If you do not see the **Detail** column, right-click any other column header and enable this column.

Message in Report

The validity of values passed to library functions shall be checked

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Code design
Category: Required
AGC Category: Required
Language: C90, C99

See Also

`MISRA C:2012 Dir 4.1`

Introduced in R2014b

MISRA C:2012 Dir 4.13

Functions which are designed to provide operations on a resource should be called in an appropriate sequence

Description

Directive Definition

Functions which are designed to provide operations on a resource should be called in an appropriate sequence.

Rationale

You typically use functions operating on a resource in the following way:

1. You allocate the resource.

   For example, you open a file or critical section.
2. You use the resource.

   For example, you read from the file or perform operations in the critical section.
3. You deallocate the resource.

   For example, you close the file or critical section.

For your functions to operate as you expect, perform the steps in sequence. For instance, if you call a resource allocation function on a certain execution path, you must call a deallocation function on that path.

Polyspace Implementation

Polyspace Bug Finder detects a violation of this rule if you specify multitasking options and your code contains one of these defects:

- `Missing lock`: A task calls an unlock function before calling the corresponding lock function.

- `Missing unlock`: A task calls a lock function but ends without a call to the corresponding unlock function.
- `Double lock`: A task calls a lock function twice without an intermediate call to an unlock function.
- `Double unlock`: A task calls an unlock function twice without an intermediate call to a lock function.

For more information on the multitasking options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server .

Message in Report

Functions which are designed to provide operations on a resource should be called in an appropriate sequence.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Multitasking: Lock Function That Is Missing Unlock Function

```
typedef signed int int32_t;
typedef signed short int16_t;

typedef struct tag_mutex_t {
    int32_t value;
} mutex_t;


extern mutex_t mutex_lock   ( void );
extern void  mutex_unlock (  mutex_t m );

extern int16_t x;
void func(void);
```

```
void task1(void) {
     func();
}

void task2(void) {
     func();
}

void func ( void ) {
    mutex_t m = mutex_lock ( );  /* Non-compliant */

    if ( x > 0 )  {
        mutex_unlock ( m );
    }  else  {
        /* Mutex not unlocked on this path */
    }
}
```

In this example, the rule is violated when:

- You specify that the functions `mutex_lock` and `mutex_unlock` are paired.

  `mutex_lock` begins a critical section and `mutex_unlock` ends it.
- The function `mutex_lock` is called. However, if `x <= 0`, the function `mutex_unlock` is not called.

To enable detection of this rule violation, you must specify these analysis options.

Option	**Specification**	
Configure multitasking manually	☑	
Entry points	`task1` `task2`	
Critical section details	**Starting routine**	**Ending routine**
	`mutex_lock`	`mutex_unlock`

For more information on the options, see:

- `Tasks (-entry-points)` For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

- `Critical section details (-critical-section-begin -critical-section-end)` For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Code design
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

Introduced in R2015b

MISRA C:2012 Dir 4.14

The validity of values received from external sources shall be checked

Description

Directive Definition

The validity of values received from external sources shall be checked.

Rationale

The values originating from external sources can be invalid because of errors or deliberate modification by attackers. Before using the data, you must check the data for validity.

For instance:

- Before using an external input as array index, you must check if it can potentially cause an array bounds error.
- Before using a variable to control a loop, you must check if it can potentially result in an infinite loop.

Message in Report

The validity of values received from external sources shall be checked.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Validity of External Values Not Checked

```
#include <stdio.h>

void f1(char from_user[])
{
        char input [128];
        (void) sscanf (from_user, "%128c", input);
        (void) sprintf ("%s", input);
}
```

In this example, the `sscanf` statement is noncompliant as there is no check to ensure that the user input is null terminated. The subsequent `sprintf` statement that outputs the string can potentially lead to an array bounds error (buffer overrun).

Check Information

Group: Code design
Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2017a

MISRA C:2012 Dir 4.3

Assembly language shall be encapsulated and isolated

Description

Directive Definition

Assembly language shall be encapsulated and isolated.

Rationale

Encapsulating assembly language is beneficial because:

- It improves readability.
- The name, and documentation, of the encapsulating macro or function makes the intent of the assembly language clear.
- All uses of assembly language for a given purpose can share encapsulation, which improves maintainability.
- You can easily substitute the assembly language for a different target or for purposes of static analysis.

Polyspace Implementation

Polyspace does not raise a warning on assembly language code encapsulated in the following:

- `asm` functions or `asm` pragmas
- Macros

Message in Report

Assembly language shall be encapsulated and isolated

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Assembly Language Code in C Function

```
enum boolVal {TRUE, FALSE};
enum boolVal isTaskActive;
void taskHandler(void);

void taskHandler(void) {
    isTaskActive = FALSE;
    // Software interrupt for task switching
    asm volatile
    (
        "SWI &02"     /* Service #1: calculate run-time */
    );
    return;
}
```

In this example, the rule violation occurs because the assembly language code is embedded directly in a C function `taskHandler` that contains other C language statements.

Correction: Encapsulate Assembly Code in Macro

One possible correction is to encapsulate the assembly language code in a macro and invoke the macro in the function `taskHandler`.

```
#define  RUN_TIME_CALC \
asm volatile \
    ( \
        "SWI &02"     /* Service #1: calculate run-Time */ \
    )\

enum boolVal {TRUE, FALSE};
enum boolVal isTaskActive;
void taskHandler(void);
```

```
void taskHandler(void) {
    isTaskActive = FALSE;
    RUN_TIME_CALC;
    return;
}
```

Check Information

Group: Code design
Category: Required
AGC Category: Required
Language: C90, C99

See Also

MISRA C:2012 Rule 1.2

Introduced in R2014b

MISRA C:2012 Dir 4.5

Identifiers in the same name space with overlapping visibility should be typographically unambiguous

Description

Directive Definition

Identifiers in the same name space with overlapping visibility should be typographically unambiguous.

Rationale

What “unambiguous” means depends on the alphabet and language in which source code is written. When you use identifiers that are typographically close, you can confuse between them.

For the Latin alphabet as used in English words, at a minimum, the identifiers should not differ by:

- The interchange of a lowercase letter with its uppercase equivalent.
- The presence or absence of the underscore character.
- The interchange of the letter `O` and the digit `0`.
- The interchange of the letter `I` and the digit `1`.
- The interchange of the letter `I` and the letter `l`.
- The interchange of the letter `S` and the digit `5`.
- The interchange of the letter `Z` and the digit `2`.
- The interchange of the letter `n` and the letter `h`.
- The interchange of the letter `B` and the digit `8`.
- The interchange of the letters `rn` and the letter `m`.

Message in Report

Identifiers in the same name space with overlapping visibility should be typographically unambiguous.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Typographically Ambiguous Identifiers

```
void func(void) {
    int id1_numval;
    int id1_num_val;  /* Non-compliant */

    int id2_numval;
    int id2_numVal;   /* Non-compliant */

    int id3_lvalue;
    int id3_Ivalue;   /* Non-compliant */

    int id4_xyz;
    int id4_xy2;      /* Non-compliant */

    int id5_zer0;
    int id5_zer0;     /* Non-compliant */

    int id6_rn;
    int id6_m;        /* Non-compliant */
}
```

In this example, the rule is violated when identifiers that can be confused for each other are used.

Check Information

Group: Code design
Category: Advisory
AGC Category: Readability
Language: C90, C99

See Also

Introduced in R2015b

MISRA C:2012 Dir 4.6

`typedefs` that indicate size and signedness should be used in place of the basic numerical types

Description

Directive Definition

`typedefs` that indicate size and signedness should be used in place of the basic numerical types.

Rationale

When the amount of memory being allocated is important, using specific-length types makes it clear how much storage is being reserved for each object.

Polyspace Implementation

The rule checker flags use of basic data types in variable or function declarations and definitions. The rule enforces use of `typedefs` instead.

The rule checker does not flag the use of basic types in the `typedef` statements themselves.

Message in Report

Typedefs that indicate size and signedness should be used in place of the basic numerical types

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Direct Use of Basic Types in Definitions

```
typedef unsigned int uint32_t;

int x = 0;       /* Non compliant */
uint32_t y = 0;  /* Compliant */
```

In this example, the declaration of `x` is noncompliant because it uses a basic type directly.

Check Information

Group: Code design
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

Introduced in R2014b

MISRA C:2012 Dir 4.7

If a function returns error information, then that error information shall be tested

Description

Directive Definition

If a function returns error information, then that error information shall be tested.

Rationale

Typically a function indicates whether an error occurred during execution, via a special return value or by another means.

If a function provides a mechanism to determine errors, before you use the function return value, you must check for such errors.

Polyspace Implementation

The checking of this directive follows the same specifications as the defect checker `Returned value of a sensitive function not checked`.

This directive is only partially supported.

Message in Report

If a function returns error information, then that error information shall be tested.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Code design
Category: Required
AGC Category: Required
Language: C90, C99

See Also

Introduced in R2017a

MISRA C:2012 Dir 4.8

If a pointer to a structure or union is never dereferenced within a translation unit, then the implementation of the object should be hidden

Description

Rule Definition

If a pointer to a structure or union is never dereferenced within a translation unit, then the implementation of the object should be hidden.

Rationale

If a pointer to a structure or union is not dereferenced in a file, the implementation details of the structure or union need not be available in the translation unit for the file. You can hide the implementation details such as structure members and protect them from unintentional changes.

Define an opaque type that can be referenced via pointers but whose contents cannot be accessed.

Polyspace Implementation

If a structure or union is defined in a file or a header file included in the file, a pointer to this structure or union declared but the pointer never dereferenced in the file, the checker flags a coding rule violation. The structure or union definition should not be visible to this file.

If you see a violation of this rule on a structure definition, identify if you have defined a pointer to the structure in the same file or in a header file included in the file. Then check if you dereference the pointer anywhere in the file. If you do not dereference the pointer, the structure definition should be hidden from this file and included header files.

Message in Report

If a pointer to a structure or union is never dereferenced within a translation unit, then the implementation of the object should be hidden.

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Examples

Object Implementation Revealed

`file.h`: Contains structure implementation.

```
#ifndef TYPE_GUARD
#define TYPE_GUARD

typedef struct  {
  int a;
} myStruct;

#endif
```

`file.c`: Includes `file.h` but does not dereference structure.

```
#include "file.h"

myStruct* getObj(void);
void useObj(myStruct*);

void func() {
  myStruct *sPtr = getObj();
  useObj(sPtr);
}
```

In this example, the pointer to the type `myStruct` is not dereferenced. The pointer is simply obtained from the `getObj` function and passed to the `useObj` function.

The implementation of `myStruct` is visible in the translation unit consisting of `file.c` and `file.h`.

Correction — Define Opaque Type

One possible correction is to define an opaque data type in the header file `file.h`. The opaque data type `ptrMyStruct` points to the `myStruct` structure without revealing what the structure contains. The structure `myStruct` itself can be defined in a separate translation unit, in this case, consisting of the file `file2.c`. The common header file `file.h` must be included in both `file.c` and `file2.c` for linking the structure definition to the opaque type definition.

`file.h`: Does not contain structure implementation.

```
#ifndef TYPE_GUARD
#define TYPE_GUARD

typedef struct myStruct *ptrMyStruct;

ptrMyStruct getObj(void);
void useObj(ptrMyStruct);

#endif
```

`file.c`: Includes `file.h` but does not dereference structure.

```
#include "file.h"

void func() {
  ptrMyStruct sPtr = getObj();
  useObj(sPtr);
}
```

`file2.c`: Includes `file.h` and dereferences structure.

```
#include "file.h"

struct myStruct {
  int a;
};

void useObj(ptrMyStruct ptr) {
    (ptr->a)++;
}
```

Check Information

Group: Code design
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

Introduced in R2018a

MISRA C:2012 Dir 4.9

A function should be used in preference to a function-like macro where they are interchangeable

Description

Directive Definition

A function should be used in preference to a function-like macro where they are interchangeable.

Rationale

In most circumstances, use functions instead of macros. Functions perform argument type-checking and evaluate their arguments once, avoiding problems with potential multiple side effects.

Polyspace Implementation

Polyspace considers all function-like macro definitions.

Message in Report

A function should be used in preference to a function-like macro where they are interchangeable

Troubleshooting

If you expect a rule violation but do not see it, refer to the documentation of Polyspace Code Prover or Polyspace Code Prover Server.

Check Information

Group: Code design
Category: Advisory
AGC Category: Advisory
Language: C90, C99

See Also

MISRA C:2012 Rule 13.2|MISRA C:2012 Rule 20.7

Introduced in R2014b

3

MISRA C++: 2008

MISRA C++:2008 Rule 0-1-1

A project shall not contain unreachable code

Description

Rule Definition

A project shall not contain unreachable code.

Rationale

This rule flags situations where a group of statements is unreachable because of syntactic reasons. For instance, code following a `return` statement are always unreachable.

Unreachable code involve unnecessary maintenance and can often indicate programming errors.

Polyspace Implementation

Bug Finder and Code Prover check this coding rule differently. The analyses can produce different results.

Message in Report

A project shall not contain unreachable code.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Unreachable statements

```
int func(int arg) {
 int temp = 0;
 switch(arg) {
     temp = arg; // Noncompliant
     case 1:
     {
         break;
     }
     default:
     {
         break;
     }
 }
 return arg;
 arg++; // Noncompliant
}
```

These statements are unreachable:

- Statements inside a `switch` statement that do not belong to a `case` or `default` block.
- Statements after a `return` statement.

Check Information

Group: Language Independent Issues
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 0-1-2

A project shall not contain infeasible paths

Description

Rule Definition

A project shall not contain infeasible paths.

Rationale

This rule flags situations where a group of statements is redundant because of nonsyntactic reasons. For instance, an `if` condition is always true or false. Code that is unreachable from syntactic reasons are flagged by rule 0-1-1.

Unreachable or redundant code involve unnecessary maintenance and can often indicate programming errors.

Polyspace Implementation

Bug Finder and Code Prover check this rule differently. The analysis can produce different results.

- Bug Finder uses the `Dead code` and `Useless if` checkers to detect violations of this rule.
- Code Prover does not use run-time checks to detect violations of this rule. Instead, Code Prover detects the violations at compile time.

Message in Report

A project shall not contain infeasible paths.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Boolean Operations with Invariant Results

```
void func (unsigned int arg) {
 if (arg >= 0U) //Noncompliant
     arg  = 1U;
 if (arg < 0U) //Noncompliant
     arg = 1U;
}
```

An `unsigned int` variable is nonnegative. Both `if` conditions involving the variable are always true or always false and are therefore redundant.

Check Information

Group: Language Independent Issues
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 0-1-3

A project shall not contain unused variables

Description

Rule Definition

A project shall not contain unused variables.

Polyspace Implementation

The checker flags local or global variables that are declared or defined but not used anywhere in the source files. This specification also applies to members of structures and classes.

Message in Report

A project shall not contain unused variables.

Variable is never used or used only in unreachable code.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of Named Bit Field for Padding

```
#include <iostream>
struct S {
    unsigned char b1 : 3;
```

```
    unsigned char pad: 1;  //Noncompliant
    unsigned char b2 : 4;
};
void init(struct S S_obj)
{
    S_obj.b1 = 0;
    S_obj.b2 = 0;
}
```

In this example, the bit field `pad` is used for padding the structure. Therefore, the field is never read or written and causes a violation of this rule. To avoid the violation, use an unnamed field for padding.

```
struct S {
    unsigned char b1 : 3;
    unsigned char : 1;
    unsigned char b2 : 4;
};
```

Check Information

Group: Language Independent Issues
Category: Required

See Also

Introduced in R2018a

MISRA C++:2008 Rule 0-1-5

A project shall not contain unused type declarations

Description

Rule Definition

A project shall not contain unused type declarations.

Rationale

If a type is declared but not used, when reviewing the code later, it is unclear if the type is redundant or left unused by mistake.

Unused types can indicate coding errors. For instance, you declared a enumerated data type for some specialized data but used an integer type for the data.

Message in Report

A project shall not contain unused type declarations.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Unused `enum` Declaration

```
enum switchValue {low, medium, high}; //Noncompliant

void operate(int userInput) {
```

```
    switch(userInput) {
        case 0: // Turn on low setting
                 break;
        case 1: // Turn on medium setting
                 break;
        case 2: // Turn on high setting
                 break;
        default: // Return error
    }
}
```

In this example, the enumerated type `switchValue` is not used. Perhaps the intention was to use the type as `switch` input like this.

```
enum switchValue {low, medium, high}; //Compliant

void operate(switchValue userInput) {
    switch(userInput) {
        case low: // Turn on low setting
                   break;
        case medium: // Turn on medium setting
                     break;
        case high: // Turn on high setting
                   break;
        default: // Return error
    }
}
```

Check Information

Group: Language Independent Issues
Category: Required

See Also

Introduced in R2018a

MISRA C++:2008 Rule 0-1-7

The value returned by a function having a non- void return type that is not an overloaded operator shall always be used

Description

Rule Definition

The value returned by a function having a non- void return type that is not an overloaded operator shall always be used.

Rationale

The unused return value might indicate a coding error or oversight.

Overloaded operators are excluded from this rule because their usage must emulate built-in operators which might not use their return value.

Polyspace Implementation

Bug Finder and Code Prover check this coding rule differently. The analyses can produce different results.

Message in Report

The value returned by a function having a non- void return type that is not an overloaded operator shall always be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Return Value Not Used

```
#include <iostream>
#include <new>

int assignMemory(int * ptr){
     int res = 1;
     ptr = new (std::nothrow) int;
     if(ptr==NULL) {
         res = 0;
     }
     return res;
}

void main() {
    int val;
    int status;

    assignMemory(&val);   //Noncompliant
    status = assignMemory(&val); //Compliant
    (void)assignMemory(&val); //Compliant

}
```

The first call to the function `assignMemory` is noncompliant because the return value is not used. The second and third calls use the return value. The return value from the second call is assigned to a local variable.

The return value from the third call is cast to `void`. Casting to `void` indicates deliberate non-use of the return value and cannot be a coding oversight.

Check Information

Group: Language Independent Issues
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 0-1-9

There shall be no dead code

Description

Rule Definition

There shall be no dead code.

Rationale

If an operation is reachable but removing the operation does not affect program behavior, the operation constitutes dead code. For instance, suppose that a variable is never read following a write operation. The write operation is redundant.

The presence of dead code can indicate an error in the program logic. Because a compiler can remove dead code, its presence can cause confusion for code reviewers.

Message in Report

There shall be no dead code.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Redundant Operations

```
#define ULIM 10000
```

```
int func(int arg) {
    int res;
    res = arg*arg + arg;
    if (res > ULIM)
        res = 0; //Noncompliant
    return arg;
}
```

In this example, the operations involving `res` are redundant because the function `func` returns its argument `arg`. All operations involving `res` can be removed without changing the effect of the function.

The checker flags the last write operation on `res` because the variable is never read after that point. The dead code can indicate an unintended coding error. For instance, you intended to return the value of `res` instead of `arg`.

Check Information

Group: Language Independent Issues
Category: Required

See Also

Introduced in R2016b

MISRA C++:2008 Rule 0-1-10

Every defined function shall be called at least once

Description

Rule Definition

Every defined function shall be called at least once.

Rationale

If a function with a definition is not called, it might indicate a serious coding error. For instance, the function call is unreachable or a different function is called unintentionally.

Polyspace Implementation

The checker detects situations where a static function is defined but not called at all in its translation unit.

Message in Report

Every defined function shall be called at least once. The static function *`funcName`* is not called.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Uncalled Static Function

```
static void func1() {
}

static void func2() { //Noncompliant
}

void func3();

int main() {
    func1();
    return 0;
}
```

The `static` function `func2` is defined but not called.

The function `func3` is not called either, however, it is only declared and not defined. The absence of a call to `func3` does not violate the rule.

Check Information

Group: Language Independent Issues
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 0-1-11

There shall be no unused parameters (named or unnamed) in nonvirtual functions

Description

Rule Definition

There shall be no unused parameters (named or unnamed) in nonvirtual functions.

Rationale

Unused parameters often indicate later design changes. You perhaps removed all uses of a specific parameter but forgot to remove the parameter from the parameter list.

Unused parameters constitute an unnecessary overhead. You can also inadvertently call the function with a different number of arguments causing a parameter mismatch.

Message in Report

There shall be no unused parameters (named or unnamed) in non-virtual functions.

Function *`funcName`* has unused parameters.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Unused Parameters

```
typedef int (*callbackFn) (int a, int b);
```

```
int callback_1 (int a, int b) { //Compliant
    return a+b;
}

int callback_2 (int a, int b) { //Noncompliant
    return a;
}

int callback_3 (int, int b) { //Compliant - flagged by Polyspace
    return b;
}

int getCallbackNumber();
int getInput();

void main() {
    callbackFn ptrFn;
    int n = getCallbackNumber();
    int x = getInput(), y = getInput();
    switch(n) {
        case 0: ptrFn = &callback_1; break;
        case 1: ptrFn = &callback_2; break;
        default: ptrFn = &callback_3; break;
    }

    (*ptrFn)(x,y);
}
```

In this example, the three functions `callback_1`, `callback_2` and `callback_3` are used as callback functions. One of the three functions is called via a function pointer depending on a value obtained at run time.

- Function `callback_1` uses all its parameters and does not violate the rule.
- Function `callback_2` does not use its parameter `a` and violates this rule.
- Function `callback_3` also does not use its first parameter but it does not violate the rule because the parameter is unnamed. However, Polyspace flags the unused parameter as a rule violation. If you see a violation of this kind, justify the violation with comments. See .

Check Information

Group: Language Independent Issues

Category: Required

See Also

Introduced in R2016b

MISRA C++:2008 Rule 0-1-12

There shall be no unused parameters (named or unnamed) in the set of parameters for a virtual function and all the functions that override it

Description

Rule Definition

There shall be no unused parameters (named or unnamed) in the set of parameters for a virtual function and all the functions that override it.

Rationale

Unused parameters often indicate later design changes. You perhaps removed all uses of a specific parameter but forgot to remove the parameter from the parameter list.

Unused parameters constitute an unnecessary overhead. You can also inadvertently call the function with a different number of arguments causing a parameter mismatch.

Polyspace Implementation

Polyspace checks for unused parameters in virtual functions within single translation units.

For instance, if a base class contains a virtual method with an unused parameter but the derived class implementation of the method uses that parameter, the rule is not violated. However, if the base class and derived class are defined in different files, the checker, which operates file by file, flags a violation of this rule on the base class.

Message in Report

There shall be no unused parameters (named or unnamed) in the set of parameters for a virtual function and all the functions that override it.

Function *`funcName`* has unused parameters.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Unused Parameter in Virtual Function

```
class base {
    public:
       virtual void assignVal (int arg1, int arg2) = 0; //Noncompliant
       virtual void assignAnotherVal (int arg1, int arg2) = 0;
};

class derived1: public base {
    public:
       virtual void assignVal (int arg1, int arg2) {
           arg1 = 0;
       }
       virtual void assignAnotherVal (int arg1, int arg2) {
           arg1 = 1;
       }
};

class derived2: public base {
    public:
       virtual void assignVal (int arg1, int arg2) {
           arg1 = 0;
       }
       virtual void assignAnotherVal (int arg1, int arg2) {
           arg2 = 1;
       }
};
```

In this example, the second parameter of the virtual method `assignVal` is not used in any of the derived class implementations of the method.

On the other hand, the implementation of the virtual method `assignAnotherVal` in derived class `derived1` uses the first parameter of the method. The implementation in

`derived2` uses the second parameter. Both parameters of `assignAnotherVal` are used and therefore the virtual method does not violate the rule.

Check Information

Group: Language Independent Issues
Category: Required

See Also

Introduced in R2016b

MISRA C++:2008 Rule 0-2-1

An object shall not be assigned to an overlapping object

Description

Rule Definition

An object shall not be assigned to an overlapping object.

Rationale

When you assign an object to another object with overlapping memory, the behavior is undefined.

The exceptions are:

- You assign an object to another object with exactly overlapping memory and compatible type.
- You copy one object to another with `memmove`.

Message in Report

An object shall not be assigned to an overlapping object.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Assignment of Union Members

```
void func (void) {
    union {
        short i;
        int j;
    } a = {0}, b = {1};

    a.j = a.i;   //Noncompliant
    a = b;       //Compliant
}
```

In this example, the rule is violated when `a.i` is assigned to `a.j` because the two variables have overlapping regions of memory.

Check Information

Group: Language Independent Issues
Category: Required

See Also

Introduced in R2016b

MISRA C++:2008 Rule 1-0-1

All code shall conform to ISO/IEC 14882:2003 "The C++ Standard Incorporating Technical Corrigendum 1"

Description

Rule Definition

All code shall conform to ISO/IEC 14882:2003 "The C++ Standard Incorporating Technical Corrigendum 1".

Polyspace Implementation

The checker reports compilation errors as detected by a compiler that strictly adheres to the C++03 Standard (ISO/IEC 14882:2003).

Bug Finder and Code Prover check this coding rule differently. The analyses can produce different results.

Message in Report

The message has two parts:

- Rule statement:

  All code shall conform to ISO/IEC 14882:2003 "The C++ Standard Incorporating Technical Corrigendum 1".
- Compilation error message such as:

  Expected a ;

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: General
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 2-3-1

Trigraphs shall not be used

Description

Rule Definition

Trigraphs shall not be used.

Rationale

You denote trigraphs with two question marks followed by a specific third character (for instance,`'??-'` represents a `'~'` (tilde) character and `'??)'` represents a `']'`). These trigraphs can cause accidental confusion with other uses of two question marks.

For instance, the string

```
"(Date should be in the form ??-??-??)"
```

is transformed to

```
"(Date should be in the form ~~]"
```

but this transformation might not be intended.

Message in Report

Trigraphs shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Lexical Conventions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 2-5-1

Digraphs should not be used

Description

Rule Definition

Digraphs should not be used.

Rationale

Digraphs are a sequence of two characters that are supposed to be treated as a single character. The checker flags use of these digraphs:

- `<%`, indicating `[`
- `%>`, indicating `]`
- `<:`, indicating `{`
- `:>`, indicating `}`
- `%:`, indicating `#`
- `%:%:`

When developing or reviewing code with digraphs, the developer or reviewer can incorrectly consider the digraph as a sequence of separate characters.

Message in Report

Digraphs should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Lexical Conventions
Category: Advisory

See Also

Introduced in R2013b

MISRA C++:2008 Rule 2-7-1

The character sequence /* shall not be used within a C-style comment

Description

Rule Definition

The character sequence / shall not be used within a C-style comment.*

Rationale

If your code contains a `/*` in a `/* */` comment, it typically means that you have inadvertently commented out code. See the example that follows.

Polyspace Implementation

You cannot justify a violation of this rule using source code annotations.

Message in Report

The character sequence /* shall not be used within a C-style comment.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of /* in /* */ Comment

```
void foo() {
    /* Initializer functions
```

```
     setup();
    /* Step functions */
}
```

In this example, the call to `setup()` is commented out because the ending `*/` is omitted, perhaps inadvertently. The checker flags this issue by highlighting the `/*` in the `/*  */` comment.

Check Information

Group: Lexical Conventions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 2-10-1

Different identifiers shall be typographically unambiguous

Description

Rule Definition

Different identifiers shall be typographically unambiguous.

Rationale

When you use identifiers that are typographically close, you can confuse between them.

The identifiers should not differ by:

- The interchange of a lowercase letter with its uppercase equivalent.
- The presence or absence of the underscore character.
- The interchange of the letter `O` and the digit `0`.
- The interchange of the letter `I` and the digit `1`.
- The interchange of the letter `I` and the letter `l`.
- The interchange of the letter `S` and the digit `5`.
- The interchange of the letter `Z` and the digit `2`.
- The interchange of the letter `n` and the letter `h`.
- The interchange of the letter `B` and the digit `8`.
- The interchange of the letters `rn` and the letter `m`.

Polyspace Implementation

The rule checker does not consider the fully qualified names of variables when checking this rule.

Bug Finder and Code Prover check this coding rule differently. The analyses can produce different results.

Message in Report

Different identifiers shall be typographically unambiguous.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Typographically Ambiguous Identifiers

```
void func(void) {
    int id1_numval;
    int id1_num_val;  /* Non-compliant */

    int id2_numval;
    int id2_numVal;   /* Non-compliant */

    int id3_lvalue;
    int id3_Ivalue;   /* Non-compliant */

    int id4_xyz;
    int id4_xy2;      /* Non-compliant */

    int id5_zerO;
    int id5_zer0;     /* Non-compliant */

    int id6_rn;
    int id6_m;        /* Non-compliant */
}
```

In this example, the rule is violated when identifiers that can be confused for each other are used.

Check Information

Group: Lexical Conventions

Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 2-10-2

Identifiers declared in an inner scope shall not hide an identifier declared in an outer scope

Description

Rule Definition

Identifiers declared in an inner scope shall not hide an identifier declared in an outer scope.

Rationale

The rule flags situations where the same identifier name is used in two variable declarations, one in an outer scope and the other in an inner scope.

```
int var;
...
{
...
  int var;
...
}
```

All uses of the name in the inner scope refers to the variable declared in the inner scope. However, a developer or code reviewer can incorrectly assume that the usage refers to the variable declared in the outer scope.

Polyspace Implementation

Bug Finder and Code Prover check this coding rule differently. The analyses can produce different results.

The rule checker does not flag situations where the same identifier name is used in different logical scopes:

- The same name is used for a class data member and a variable outside the class.
- The same name is used for a method in a base and derived class.

Message in Report

Identifiers declared in an inner scope shall not hide an identifier declared in an outer scope.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Local Variable Hiding Global Variable

```
int varInit = 1;

void doSomething(void);

void step(void) {
    int varInit = 0; //Noncompliant
    if(varInit)
       doSomething();
}
```

In this example, `varInit` defined in `func` hides the global variable `varInit`. The `if` condition refers to the local `varInit` and the block is unreachable, but you might expect otherwise.

Check Information

Group: Lexical Conventions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 2-10-3

A typedef name (including qualification, if any) shall be a unique identifier

Description

Rule Definition

A typedef name (including qualification, if any) shall be a unique identifier.

Rationale

The rule flags identifier declarations where the identifier name is the same as a previously declared typedef name. When you use identifiers that are identical, you can confuse between them.

Polyspace Implementation

The checker does not flag situations where the conflicting names occur in different namespaces.

Bug Finder and Code Prover check this coding rule differently. The analyses can produce different results.

Message in Report

A typedef name (including qualification, if any) shall be a unique identifier.

Identifier *`typeName`* should not be reused.

Already used as typedef name (*`fileName lineNumber`*).

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Typedef Name Conflicting with Other Identifiers

```
namespace NS1 {
    typedef int WIDTH;
}

namespace NS2 {
    float WIDTH; //Compliant
}

void f1() {
    typedef int TYPE;
}

void f2() {
    float TYPE; //Noncompliant
}
```

In this example, the declaration of `TYPE` in `f2()` conflicts with a typedef declaration in `f1()`.

The checker does not flag the redeclaration of `WIDTH` because the two declarations belong to different namespaces.

Check Information

Group: Lexical Conventions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 2-10-4

A class, union or enum name (including qualification, if any) shall be a unique identifier

Description

Rule Definition

A class, union or enum name (including qualification, if any) shall be a unique identifier.

Rationale

The rule flags identifier declarations where the identifier name is the same as a previously declared class, union or typedef name. When you use identifiers that are identical, you can confuse between them.

Polyspace Implementation

The checker does not flag situations where the conflicting names occur in different namespaces.

Bug Finder and Code Prover check this coding rule differently. The analyses can produce different results.

Message in Report

A class, union or enum name (including qualification, if any) shall be a unique identifier.

Identifier *`tagName`* should not be reused.

Already used as tag name (*`fileName lineNumber`*).

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Typedef Name Conflicting with Other Identifiers

```
void f1() {
    class floatVar {};
}

void f2() {
    float floatVar; //Noncompliant
}
```

In this example, the declaration of `floatVar` in `f2()` conflicts with a class declaration in `f1()`.

Check Information

Group: Lexical Conventions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 2-10-5

The identifier name of a non-member object or function with static storage duration should not be reused

Description

Rule Definition

The identifier name of a non-member object or function with static storage duration should not be reused.

Rationale

The rule flags situations where the name of an identifier with static storage duration is reused. The rule applies even if the identifiers belong to different namespaces because the reuse leaves the chance that you mistake one identifier for the other.

Polyspace Implementation

The rule checker flags redefined functions only when there is a declaration.

Bug Finder and Code Prover check this coding rule differently. The analyses can produce different results.

Message in Report

The identifier name of a non-member object or function with static storage duration should not be reused.

Identifier *`name`* should not be reused.

Already used as static identifier with static storage duration (*`fileName lineNumber`*).

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Reuse of Identifiers in Different Namespaces

```
namespace NS1 {
    static int WIDTH;
}

namespace NS2 {
    float WIDTH; //Noncompliant
}
```

In this example, the identifier name `WIDTH` is reused in the two namespaces `NS1` and `NS2`.

Check Information

Group: Lexical Conventions
Category: Advisory

See Also

Introduced in R2013b

MISRA C++:2008 Rule 2-10-6

If an identifier refers to a type, it shall not also refer to an object or a function in the same scope

Description

Rule Definition

If an identifier refers to a type, it shall not also refer to an object or a function in the same scope.

Rationale

For compatibility with C, in C++, you are allowed to use the same name for a type and an object or function. However, the name reuse can cause confusion during development or code review.

Polyspace Implementation

If the identifier is a function and the function is both declared and defined, then the violation is reported only once.

Bug Finder and Code Prover check this coding rule differently. The analyses can produce different results.

Message in Report

If an identifier refers to a type, it shall not also refer to an object or a function in the same scope.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Reuse of Name for Type and Object

```
struct vector{
    int x;
    int y;
    int z;
}vector; //Noncompliant
```

In this example, the name `vector` is used both for the structured data type and for an object of that type.

Check Information

Group: Lexical Conventions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 2-13-1

Only those escape sequences that are defined in ISO/IEC 14882:2003 shall be used

Description

Rule Definition

Only those escape sequences that are defined in ISO/IEC 14882:2003 shall be used.

Rationale

Escape sequences are certain special characters represented in string and character literals. They are written with a backslash (\) followed by a character.

The C++ Standard (ISO/IEC 14882:2003, Sec. 2.13.2) defines a list of escape sequences. See Escape Sequences. Use of escape sequences (backslash followed by character) outside that list leads to undefined behavior.

Message in Report

Only those escape sequences that are defined in ISO/IEC 14882:2003 shall be used.

`\`*`char`* is not an ISO/IEC escape sequence.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Incorrect Escape Sequences

```
void func () {
  const char a[2] = "\k"; \\Noncompliant
  const char b[2] = "\b"; \\Compliant
}
```

In this example, `\k` is not a recognized escape sequence.

Check Information

Group: Lexical Conventions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 2-13-2

Octal constants (other than zero) and octal escape sequences (other than "\0") shall not be used

Description

Rule Definition

Octal constants (other than zero) and octal escape sequences (other than "\0") shall not be used.

Rationale

Octal constants are denoted by a leading zero. A developer or code reviewer can mistake an octal constant as a decimal constant with a redundant leading zero.

Octal escape sequences beginning with \ can also cause confusion. Inadvertently introducing an 8 or 9 in the digit sequence after \ breaks the escape sequence and introduces a new digit. A developer or code reviewer can ignore this issue and continue to treat the escape sequence as one digit.

Message in Report

Octal constants (other than zero) and octal escape sequences (other than "\0") shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of Octal Constants and Octal Escape Sequences

```
void func(void) {
  int busData[6];

  busData[0] = 100;
  busData[1] = 108;
  busData[2] = 052;      //Noncompliant
  busData[3] = 071;      //Noncompliant
  busData[4] = '\109';   //Noncompliant
  busData[5] = '\100';   //Noncompliant

}
```

The checker flags all octal constants (other than zero) and all octal escape sequences (other than `\0`).

In this example:

- The octal escape sequence contains the digit 9, which is not an octal digit. This escape sequence has implementation-defined behavior.
- The octal escape sequence `\100` represents the number 64, but the rule checker forbids this use.

Check Information

Group: Lexical Conventions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 2-13-3

A "U" suffix shall be applied to all octal or hexadecimal integer literals of unsigned type

Description

Rule Definition

A "U" suffix shall be applied to all octal or hexadecimal integer literals of unsigned type.

Rationale

The signedness of a constant is determined from:

- Value of the constant.
- Base of the constant: octal, decimal or hexadecimal.
- Size of the various types.
- Any suffixes used.

Unless you use a suffix `u` or `U`, another developer looking at your code cannot determine easily whether a constant is signed or unsigned.

Message in Report

A "U" suffix shall be applied to all octal or hexadecimal integer literals of unsigned type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Lexical Conventions

Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 2-13-4

Literal suffixes shall be upper case

Description

Rule Definition

Literal suffixes shall be upper case.

Rationale

Literal constants can end with the letter `l` (el). Enforcing literal suffixes to be upper case removes potential confusion between the letter `l` and the digit `1`.

For consistency, use upper case constants for other suffixes such as `U` (unsigned) and `F` (float).

Message in Report

Literal suffixes shall be upper case.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of Literal Constants with Lower Case Suffix

```
const int a = 0l; //Noncompliant
const int b = 0L; //Compliant
```

In this example, both `a` and `b` are assigned the same literal constant. However, from a quick glance, one can mistakenly assume that `a` is assigned the value `01` (octal one).

Check Information

Group: Lexical Conventions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 2-13-5

Narrow and wide string literals shall not be concatenated

Description

Rule Definition

Narrow and wide string literals shall not be concatenated.

Rationale

Narrow string literals are enclosed in double quotes without a prefix. Wide string literals are enclosed in double quotes with a prefix `L` outside the quotes. See string literals.

Concatenation of narrow and wide string literals can lead to undefined behavior.

Message in Report

Narrow and wide string literals shall not be concatenated.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Concatenation of Narrow and Wide String Literals

```
char array[] = "Hello" "World";
wchar_t w_array[] = L"Hello" L"World";
wchar_t mixed[] = "Hello" L"World"; //Noncompliant
```

In this example, in the initialization of the array `mixed`, the narrow string literal `"Hello"` is concatenated with the wide string literal `L"World"`.

Check Information

Group: Lexical Conventions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 3-1-1

It shall be possible to include any header file in multiple translation units without violating the One Definition Rule

Description

Rule Definition

It shall be possible to include any header file in multiple translation units without violating the One Definition Rule.

Rationale

If a header file with variable or function definitions appears in multiple inclusion paths, the header file violates the One Definition Rule possibly leading to unpredictable behavior. For instance, a source file includes the header file `include.h` and another header file, which also includes `include.h`.

Polyspace Implementation

The rule checker flags variable and function definitions in header files.

Message in Report

It shall be possible to include any header file in multiple translation units without violating the One Definition Rule.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Basic Concepts
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 3-1-2

Functions shall not be declared at block scope

Description

Rule Definition

Functions shall not be declared at block scope.

Rationale

It is a good practice to place all declarations at the namespace level.

Additionally, if you declare a function at block scope, it is often not clear if the statement is a function declaration or an object declaration with a call to the constructor.

Message in Report

Functions shall not be declared at block scope.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Function Declarations at Block Scope

```
class A {
};

void b1() {
```

```
    void func(); //Noncompliant
    A a();   //Noncompliant
}
```

In this example, the declarations of `func` and `a` are in the block scope of `b1`.

The second function declaration can cause confusion because it is not clear if `a` is a function that returns an object of type `A` or `a` is itself an object of type `A`.

Check Information

Group: Basic Concepts
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 3-1-3

When an array is declared, its size shall either be stated explicitly or defined implicitly by initialization

Description

Rule Definition

When an array is declared, its size shall either be stated explicitly or defined implicitly by initialization.

Rationale

Though you can declare an incomplete array type and later complete the type, specifying the array size during the first declaration makes the subsequent array access less error-prone.

Message in Report

When an array is declared, its size shall either be stated explicitly or defined implicitly by initialization.

Size of array *`arrayName`* should be explicitly stated.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Array Size Unspecified During Declaration

```
int array[10];
extern int array2[]; //Noncompliant
int array3[]= {0,1,2};
extern int array4[10];
```

In the declaration of `array2`, the array size is unspecified.

Check Information

Group: Basic Concepts
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 3-2-1

All declarations of an object or function shall have compatible types

Description

Rule Definition

All declarations of an object or function shall have compatible types.

Rationale

If the declarations of an object or function in two different translation units have incompatible types, the behavior is undefined.

Message in Report

All declarations of an object or function shall have compatible types.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Basic Concepts
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 3-2-2

The One Definition Rule shall not be violated

Description

Rule Definition

The One Definition Rule shall not be violated.

Rationale

Violations of the One Definition Rule leads to undefined behavior.

Polyspace Implementation

The checker flags situations where the same function or object has multiple definitions and the definitions differ by some token.

Message in Report

The One Definition Rule shall not be violated.

Declaration of class *`className`* violates the One Definition Rule:

it conflicts with other declaration (*`fileName lineNumber`*).

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Different Tokens in Same Type Definition

This example uses two files:

- `file1.cpp`:

```
struct S
{
   int x;
   int y;
};
```

- `file2.cpp`:

```
struct S
{
   int y;
   int x;
};
```

In this example, both `file1.cpp` and `file2.cpp` define the structure `S`. However, the definitions switch the order of the structure fields.

Check Information

Group: Basic Concepts
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 3-2-3

A type, object or function that is used in multiple translation units shall be declared in one and only one file

Description

Rule Definition

A type, object or function that is used in multiple translation units shall be declared in one and only one file.

Rationale

If you declare an identifier in a header file, you can include the header file in any translation unit where the identifier is defined or used. In this way, you ensure consistency between:

- The declaration and the definition.
- The declarations in different translation units.

The rule enforces the practice of declaring external objects or functions in header files.

Message in Report

A type, object or function that is used in multiple translation units shall be declared in one and only one file.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Basic Concepts
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 3-2-4

An identifier with external linkage shall have exactly one definition

Description

Rule Definition

An identifier with external linkage shall have exactly one definition.

Rationale

If an identifier has multiple definitions or no definitions, it can lead to undefined behavior.

Message in Report

An identifier with external linkage shall have exactly one definition.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Multiple Definitions of Identifier

This example uses two files:

- `file1.cpp`:

  ```
  int x = 0;
  ```
- `file2.cpp`:

```
int x = 1;
```

The same identifier `x` is defined in both files.

Check Information

Group: Basic Concepts
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 3-3-1

Objects or functions with external linkage shall be declared in a header file

Description

Rule Definition

Objects or functions with external linkage shall be declared in a header file.

Rationale

If you declare a function or object in a header file, it is clear that the function or object is meant to be accessed in multiple translation units. If you intend to access the function or object from a single translation unit, declare it `static` or in an unnamed namespace.

Message in Report

Objects or functions with external linkage shall be declared in a header file.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Declaration in Header File Missing

This example uses two files:

- `decls.h`:

  ```
  extern int x;
  ```

- `file.cpp`:

```
#include "decls.h"

int x = 0;
int y = 0; //Noncompliant
static int z = 0;
```

In this example, the variable `x` is declared in a header file but the variable `y` is not. The variable `z` is also not declared in a header file but it is declared with the `static` specifier and does not have external linkage.

Check Information

Group: Basic Concepts
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 3-3-2

If a function has internal linkage then all re-declarations shall include the static storage class specifier

Description

Rule Definition

If a function has internal linkage then all re-declarations shall include the static storage class specifier.

Rationale

If a function declaration has the `static` storage class specifier, it has internal linkage. Subsequent redeclarations of the function have internal linkage even without the `static` specifier.

However, if you do not specify the `static` keyword explicitly, it is not immediately clear from a declaration whether the function has internal linkage.

Message in Report

If a function has internal linkage then all re-declarations shall include the static storage class specifier.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Missing `static` Specifier from Redeclaration

```
static void func1 ();
static void func2 ();

void func1() {}  //Noncompliant
static void func2() {}
```

In this example, the function `func1` is declared `static` but defined without the `static` specifier.

Check Information

Group: Basic Concepts
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 3-4-1

An identifier declared to be an object or type shall be defined in a block that minimizes its visibility

Description

Rule Definition

An identifier declared to be an object or type shall be defined in a block that minimizes its visibility.

Rationale

Defining variables with the minimum possible block scope reduces the possibility that they might later be accessed unintentionally.

For instance, if an object is meant to be accessed in one function only, declare the object local to the function.

Polyspace Implementation

The rule checker determines if an object is used in one block only. If the object is used in one block but defined outside the block, the checker raises a violation.

Message in Report

An identifier declared to be an object or type shall be defined in a block that minimizes its visibility.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of Global Variable in Single Function

```
static int countReset; //Noncompliant

volatile int check;

void increaseCount() {
    int count = countReset;
    while(check%2) {
     count++;
    }
}
```

In this example, the variable `countReset` is declared global used in one function only. A compliant solution declares the variable local to the function to reduce its visibility.

Check Information

Group: Basic Concepts
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 3-9-1

The types used for an object, a function return type, or a function parameter shall be token-for-token identical in all declarations and re-declarations

Description

Rule Definition

The types used for an object, a function return type, or a function parameter shall be token-for-token identical in all declarations and re-declarations.

Rationale

If a redeclaration is not token-for-token identical to the previous declaration, it is not clear from visual inspection which object or function is being redeclared.

Polyspace Implementation

The rule checker compares the current declaration with the last seen declaration.

Message in Report

The types used for an object, a function return type, or a function parameter shall be token-for-token identical in all declarations and re-declarations.

Variable *varName* is not compatible with previous declaration.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Identical Declarations That Do Not Match Token for Token

```
typedef int* intptr;

int* map;
extern intptr map; //Noncompliant

intptr table;
extern intptr table; //Compliant
```

In this example, the variable `map` is declared twice. The second declaration uses a `typedef` which resolves to the type of the first declaration. Because of the `typedef`, the second declaration is not token-for-token identical to the first.

Check Information

Group: Basic Concepts
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 3-9-2

typedefs that indicate size and signedness should be used in place of the basic numerical types

Description

Rule Definition

typedefs that indicate size and signedness should be used in place of the basic numerical types.

Rationale

When the amount of memory being allocated is important, using specific-length types makes it clear how much storage is being reserved for each object.

Polyspace Implementation

The rule checker does not raise violations in templates that are not instantiated.

Message in Report

typedefs that indicate size and signedness should be used in place of the basic numerical types.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Direct Use of Basic Numerical Types

```
typedef unsigned int uint32_t;

unsigned int x = 0;       //Noncompliant
uint32_t y = 0;  //Compliant
```

In this example, the declaration of `x` is noncompliant because it uses the basic type `int` directly.

Check Information

Group: Basic Concepts
Category: Advisory

See Also

Introduced in R2013b

MISRA C++:2008 Rule 3-9-3

The underlying bit representations of floating-point values shall not be used

Description

Rule Definition

The underlying bit representations of floating-point values shall not be used.

Rationale

The underlying bit representations of floating point values vary across compilers. If you directly use the underlying representation of floating point values, your program is not portable across implementations.

Polyspace Implementation

The rule checker flags conversions from pointers to floating point types into pointers to integer types, and vice versa.

Message in Report

The underlying bit representations of floating-point values shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Using Underlying Representation of Floating-Point Values

```
float fabs2(float f) {
    unsigned int* ptr = reinterpret_cast <unsigned int*> (&f); //Noncompliant
    *(ptr + 3) &= 0x7f;
    return f;
}
```

In this example, the `reinterpret_cast` attempts to cast a floating-point value to an integer and access the underlying bit representation of the floating point value.

Check Information

Group: Basic Concepts
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 4-5-1

Expressions with type bool shall not be used as operands to built-in operators other than the assignment operator =, the logical operators &&, ||, !, the equality operators == and !=, the unary & operator, and the conditional operator

Description

Rule Definition

Expressions with type bool shall not be used as operands to built-in operators other than the assignment operator =, the logical operators &&, ||, !, the equality operators == and !=, the unary & operator, and the conditional operator.

Rationale

Operators other than the ones mentioned in the rule do not produce meaningful results with `bool` operands. Use of `bool` operands with these operators can indicate programming errors. For instance, you intended to use the logical operator `||` but used the bitwise operator `|` instead.

Message in Report

Expressions with type bool shall not be used as operands to built-in operators other than the assignment operator =, the logical operators &&, ||, !, the equality operators == and !=, the unary & operator, and the conditional operator.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Compliant and Noncompliant Uses of `bool` Operands

```
void boolOperations() {
    bool lhs = true;
    bool rhs = false;

    int res;

    if(lhs & rhs) {} //Noncompliant
    if(lhs < rhs) {} //Noncompliant
    if(~rhs) {}      //Noncompliant
    if(lhs ^ rhs) {} //Noncompliant
    if(lhs == rhs) {} //Compliant
    if(!rhs) {}       //Compliant
    res = lhs? -1:1;  //Compliant
}
```

In this example, `bool` operands do not violate the rule when used with the `==`, `!` and the `?` operators.

Check Information

Group: Standard Conversions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 4-5-2

Expressions with type enum shall not be used as operands to built- in operators other than the subscript operator [ ], the assignment operator =, the equality operators == and !=, the unary & operator, and the relational operators <, <=, >, >=

Description

Rule Definition

Expressions with type enum shall not be used as operands to built- in operators other than the subscript operator [ ], the assignment operator =, the equality operators == and !=, the unary & operator, and the relational operators <, <=, >, >=.

Message in Report

Expressions with type enum shall not be used as operands to built- in operators other than the subscript operator [ ], the assignment operator =, the equality operators == and !=, the unary & operator, and the relational operators <, <=, >, >=.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Standard Conversions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 4-5-3

Expressions with type (plain) char and wchar_t shall not be used as operands to built-in operators other than the assignment operator =, the equality operators == and !=, and the unary & operator N

Description

Rule Definition

Expressions with type (plain) char and wchar_t shall not be used as operands to built-in operators other than the assignment operator =, the equality operators == and !=, and the unary & operator. N

Rationale

The C++03 Standard only requires that the characters `'0'` to `'9'` have consecutive values. Other characters do not have well-defined values. If you use these characters in operations other than the ones mentioned in the rule, you implicitly use their underlying values and might see unexpected results.

Message in Report

Expressions with type (plain) char and wchar_t shall not be used as operands to built-in operators other than the assignment operator =, the equality operators == and !=, and the unary & operator. N

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Compliant and Noncompliant Uses of Character Operands

```
void charManipulations (char ch) {

    char initChar = 'a'; //Compliant
    char finalChar = 'z'; //Compliant

    if(ch == initChar) {} //Compliant
    if( (ch >= initChar) && (ch <= finalChar)) {} //Noncompliant
    else if( (ch >= '0') && (ch <= '9') ) {} //Compliant by exception
}
```

In this example, character operands do not violate the rule when used with the = and == operators. Character operands can also be used with relational operators as long as the comparison is performed with the digits `'0'` to `'9'`.

Check Information

Group: Standard Conversions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 4-10-1

NULL shall not be used as an integer value

Description

Rule Definition

NULL shall not be used as an integer value.

Rationale

In C++, you can use the literals 0 and NULL as both an integer and a null pointer constant. However, use of 0 as a null pointer constant or NULL as an integer can cause developer confusion.

This rule restricts the use of NULL to null pointer constants. `MISRA C++:2008 Rule 4-10-2` restricts the use of the literal 0 to integers.

Polyspace Implementation

The checker flags assignment of NULL to an integer variable or binary operations involving NULL and an integer. Assignments can be direct or indirect such as passing NULL as integer argument to a function.

Message in Report

NULL shall not be used as an integer value.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Compliant and Noncompliant Uses of NULL

```
#include <cstddef>

void checkInteger(int);
void checkPointer(int *);

void main() {
    checkInteger(NULL); //Noncompliant
    checkPointer(NULL); //Compliant
}
```

In this example, the use of `NULL` as argument to the `checkInteger` function is noncompliant because the function expects an `int` argument.

Check Information

Group: Standard Conversions
Category: Required

See Also

Introduced in R2018a

MISRA C++:2008 Rule 4-10-2

Literal zero (0) shall not be used as the null-pointer-constant

Description

Rule Definition

Literal zero (0) shall not be used as the null-pointer-constant.

Rationale

In C++, you can use the literals 0 and NULL as both an integer and a null pointer constant. However, use of 0 as a null pointer constant or NULL as an integer can cause developer confusion.

This rule restricts the use of the literal 0 to integers. `MISRA C++:2008 Rule 4-10-1` restricts the use of NULL to null pointer constants.

Polyspace Implementation

The checker flags assignment of 0 to a pointer variable or binary operations involving 0 and a pointer. Assignments can be direct or indirect such as passing 0 as pointer argument to a function.

Message in Report

Literal zero (0) shall not be used as the null-pointer-constant.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Compliant and Noncompliant Uses of Literal 0

```
#include <cstddef>

void checkInteger(int);
void checkPointer(int *);

void main() {
    checkInteger(0); //Compliant
    checkPointer(0); //Noncompliant
}
```

In this example, the use of 0 as argument to the `checkPointer` function is noncompliant because the function expects an `int *` argument.

Check Information

Group: Standard Conversions
Category: Required

See Also

Introduced in R2018a

MISRA C++:2008 Rule 5-0-1

The value of an expression shall be the same under any order of evaluation that the standard permits

Description

Rule Definition

The value of an expression shall be the same under any order of evaluation that the standard permits.

Rationale

If an expression results in different values depending on the order of evaluation, its value becomes implementation-defined.

Polyspace Implementation

An expression can have different values under the following conditions:

- The same variable is modified more than once in the expression, or is both read and written.
- The expression allows more than one order of evaluation.

Therefore, the rule checker forbids expressions where a variable is modified more than once and can cause different results under different orders of evaluation. The rule checker also detects cases where a volatile variable is read more than once in an expression.

Message in Report

The value of an expression shall be the same under any order of evaluation that the standard permits.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Variable Modified More Than Once in Expression

```
int a[10], b[10];
#define COPY_ELEMENT(index) (a[(index)]=b[(index)])

void main () {
    int i=0, k=0;

    COPY_ELEMENT (k);         /* Compliant */
    COPY_ELEMENT (i++);       /* Non-compliant  */
}
```

In this example, the rule is violated by the statement `COPY_ELEMENT(i++)` because `i++` occurs twice and the order of evaluation of the two expressions is unspecified.

Variable Modified and Used in Multiple Function Arguments

```
void f (unsigned int param1, unsigned int param2) {}

void main () {
    unsigned int i=0;
    f ( i++, i );                 /* Non-compliant */
}
```

In this example, the rule is violated because it is unspecified whether the operation `i++` occurs before or after the second argument is passed to `f`. The call `f(i++,i)` can translate to either `f(0,0)` or `f(0,1)`.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-0-2

Limited dependence should be placed on C++ operator precedence rules in expressions

Description

Rule Definition

Limited dependence should be placed on C++ operator precedence rules in expressions.

Rationale

Use parentheses to clearly indicate the order of evaluation.

Depending on operator precedence can cause the following issues:

- If you or another code reviewer reviews the code, the intended order of evaluation is not immediately clear.
- It is possible that the result of the evaluation does not meet your expectations. For instance:
  - In the operation `*p++`, it is possible that you expect the dereferenced value to be incremented. However, the pointer `p` is incremented before the dereference.
  - In the operation `(x == y | z)`, it is possible that you expect `x` to be compared with `y | z`. However, the == operation happens before the `|` operation.

Message in Report

Limited dependence should be placed on C++ operator precedence rules in expressions.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Evaluation Order Dependent on Operator Precedence Rules

```
#include <cstdio>

void showbits(unsigned int x) {
    for(int i = (sizeof(int) * 8) - 1; i >= 0; i--) {
       (x & 1u << i) ? putchar('1') : putchar('0'); // Noncompliant
    }
    printf("\n");
}
```

In this example, the checker flags the operation `x & 1u << i` because the statement relies on operator precedence rules for the `<<` operation to happen before the `&` operation. If this is the intended order, the operation can be rewritten as `x & (1u << i)`.

Check Information

Group: Expressions
Category: Advisory

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-0-3

A cvalue expression shall not be implicitly converted to a different underlying type

Description

Rule Definition

A cvalue expression shall not be implicitly converted to a different underlying type.

Rationale

This rule ensures that the result of the expression does not overflow when converted to a different type.

Polyspace Implementation

Expressions flagged by this checker follow the detailed specifications for cvalue expressions from the MISRA C++ documentation.

The underlying data type of a cvalue expression is the widest of operand data types in the expression. For instance, if you add two variables, one of type `int8_t` (`typedef` for `char`) and another of type `int32_t` (`typedef` for `int`), the addition has underlying type `int32_t`. If you assign the sum to a variable of type `int8_t`, the rule is violated.

Message in Report

A cvalue expression shall not be implicitly converted to a different underlying type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Implicit Conversion of Cvalue Expression

```
typedef char int8_t;
typedef signed int int32_t;

void func ( )
  {
    int32_t s32;
    int8_t s8;
    s32 = s8 + s8; //Noncompliant
    s32 = s32 + s8; //Compliant
  }
```

In this example, the rule is violated when two variables of type `int8_t` are added and the result is assigned to a variable of type `int32_t`. The underlying type of the addition does not take into account the integer promotion involved and is simply the widest of operand data types, in this case, `int8_t`.

The rule is not violated if one of the operands has type `int32_t` and the result is assigned to a variable of type `int32_t`. In this case, the underlying data type of the addition is the same as the type of the variable to which the result is assigned.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-0-4

An implicit integral conversion shall not change the signedness of the underlying type

Description

Rule Definition

An implicit integral conversion shall not change the signedness of the underlying type.

Rationale

Some conversions from signed to unsigned data types can lead to implementation-defined behavior. You can see unexpected results from the conversion.

Polyspace Implementation

The checker flags implicit conversions from a signed to an unsigned integer data type or vice versa.

The checker assumes that `ptrdiff_t` is a signed integer.

Message in Report

An implicit integral conversion shall not change the signedness of the underlying type.

Implicit conversion of one of the binary + operands whose underlying types are *`typename_1`* and *`typename_2`*.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Implicit Conversions that Change Signedness

```
typedef char int8_t;
typedef unsigned char uint8_t;

void func()
  {
    int8_t s8;
    uint8_t u8;

    s8 = u8; //Noncompliant
    u8 = s8 + u8; //Noncompliant
    u8 = static_cast< uint8_t > ( s8 ) + u8; //Compliant
}
```

In this example, the rule is violated when a variable with a variable with signed data type is implicitly converted to a variable with unsigned data type or vice versa. If the conversion is explicit, as in the preceding example, the rule violation does not occur.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-0-5

There shall be no implicit floating-integral conversions

Description

Rule Definition

There shall be no implicit floating-integral conversions.

Rationale

If you convert from a floating point to an integer type, you lose information. Unless you explicitly cast from floating point to an integer type, it is not clear whether the loss of information is intended. Additionally, if the floating-point value cannot be represented in the integer type, the behavior is undefined.

Conversion from an integer to floating-point type can result in an inexact representation of the value. The error from conversion can accumulate over later operations and lead to unexpected results.

Polyspace Implementation

The checker flags implicit conversions between floating-point types (`float` and `double`) and integer types (`short`, `int`, etc.).

This rule takes precedence over 5-0-4 and 5-0-6 if they apply at the same time.

Message in Report

There shall be no implicit floating-integral conversions.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Conversion Between Floating Point and Integer Types

```
typedef signed int int32_t;
typedef float float32_t;

void func ( )
  {
    float32_t f32;
    int32_t   s32;
    s32 = f32;   //Noncompliant
    f32 = s32;   //Noncompliant
    f32 = static_cast< float32_t > ( s32 ); //Compliant
  }
```

In this example, the rule is violated when a floating-point type is *implicitly* converted to an integer type. The violation does not occur if the conversion is explicit.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-0-6

An implicit integral or floating-point conversion shall not reduce the size of the underlying type

Description

Rule Definition

An implicit integral or floating-point conversion shall not reduce the size of the underlying type.

Rationale

A conversion that reduces the size of the underlying type can result in loss of information. Unless you explicitly cast to the narrower type, it is not clear whether the loss of information is intended.

Polyspace Implementation

The checker flags implicit conversions that reduce the size of a type.

If the conversion is to a narrower integer with a different sign, then rule 5-0-4 takes precedence over rule 5-0-6. Only rule 5-0-4 is shown.

Message in Report

An implicit integral or floating-point conversion shall not reduce the size of the underlying type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Conversion That Reduces Size of Type

```
typedef signed short int16_t;
typedef signed int int32_t;

void func ( )
  {
    int16_t   s16;;
    int32_t   s32;
    s16 = s32;   //Noncompliant
    s16 = static_cast< int16_t > ( s32 ); //Compliant
  }
```

In this example, the rule is violated when a type is *implicitly* converted to a narrower type. The violation does not occur if the conversion is explicit.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-0-7

There shall be no explicit floating-integral conversions of a cvalue expression

Description

Rule Definition

There shall be no explicit floating-integral conversions of a cvalue expression.

Rationale

Expressions flagged by this checker follow the detailed specifications for cvalue expressions from the MISRA C++ documentation.

If you evaluate an expression and later cast the result to a different type, the cast has no effect on the underlying type of the evaluation (the widest of operand data types in the expression). For instance, in this example, the result of an integer division is then cast to a floating-point type.

```
short num;
short den;
float res;
res= static_cast<float> (num/den);
```

However, a developer or code reviewer can expect that the evaluation uses the data type to which the result is cast later. For instance, one can expect a floating-point division because of the later cast.

Message in Report

There shall be no explicit floating-integral conversions of a cvalue expression.

Complex expression of underlying type *`typeBeforeConversion`* may only be cast to narrower integer type of same signedness, however the destination type is *`typeAfterconversion`*.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Conversion of Division Result from Integer to Floating Point

```
void func() {
     short num;
     short den;
     short res_short;
     float res_float;

     res_float = static_cast<float> (num/den); //Noncompliant

     res_short = num/den;
     res_short = static_cast<float> (res_float); //Compliant

}
```

In this example, the first cast on the division result violates the rule but the second cast does not.

- The first cast can lead to the incorrect expectation that the expression is evaluated with an underlying type `float`.
- The second cast makes it clear that the expression is evaluated with the underlying type `short`. The result is then cast to the type `float`.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-0-8

An explicit integral or floating-point conversion shall not increase the size of the underlying type of a cvalue expression

Description

Rule Definition

An explicit integral or floating-point conversion shall not increase the size of the underlying type of a cvalue expression.

Rationale

Expressions flagged by this checker follow the detailed specifications for cvalue expressions from the MISRA C++ documentation.

If you evaluate an expression and later cast the result to a different type, the cast has no effect on the underlying type of the evaluation (the widest of operand data types in the expression). For instance, in this example, the sum of two `short` operands is cast to the wider type `int`.

```
short op1;
short op2;
int res;
res= static_cast<int> (op1 + op2);
```

However, a developer or code reviewer can expect that the evaluation uses the data type to which the result is cast later. For instance, one can expect a sum with the underlying type `int` because of the later cast.

Message in Report

An explicit integral or floating-point conversion shall not increase the size of the underlying type of a cvalue expression.

Complex expression of underlying type *typeBeforeConversion* may only be cast to narrower integer type of same signedness, however the destination type is *typeAfterconversion*.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Conversion of Sum to Wider Integer Type

```
void func() {
     short op1;
     short op2;
     int res;

     res = static_cast<int> (op1 + op2); //Noncompliant
     res = static_cast<int> (op1) + op2; //Compliant

}
```

In this example, the first cast on the sum violates the rule but the second cast does not.

- The first cast can lead to the incorrect expectation that the sum is evaluated with an underlying type `int`.
- The second cast first converts one of the operands to `int` so that the sum is actually evaluated with the underlying type `int`.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-0-9

An explicit integral conversion shall not change the signedness of the underlying type of a cvalue expression

Description

Rule Definition

An explicit integral conversion shall not change the signedness of the underlying type of a cvalue expression.

Rationale

Expressions flagged by this checker follow the detailed specifications for cvalue expressions from the MISRA C++ documentation.

If you evaluate an expression and later cast the result to a different type, the cast has no effect on the underlying type of the evaluation (the widest of operand data types in the expression).. For instance, in this example, the sum of two `unsigned int` operands is cast to the type `int`.

```
unsigned int op1;
unsigned int op2;
int res;
res= static_cast<int> (op1 + op2);
```

However, a developer or code reviewer can expect that the evaluation uses the data type to which the result is cast later. For instance, one can expect a sum with the underlying type `int` because of the later cast.

Message in Report

An explicit integral conversion shall not change the signedness of the underlying type of a cvalue expression.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Conversion of Sum to Wider Integer Type

```
typedef int int32_t;
typedef unsigned int uint32_t;

void func() {
     uint32_t op1;
     uint32_t op2;
     int32_t res;

     res = static_cast<int32_t> (op1 + op2); //Noncompliant
     res = static_cast<int32_t> (op1) +
           static_cast<int32_t> (op2); //Compliant

}
```

In this example, the first cast on the sum violates the rule but the second cast does not.

- The first cast can lead to the incorrect expectation that the sum is evaluated with an underlying type `int32_t`.
- The second cast first converts each of the operands to `int32_t` so that the sum is actually evaluated with the underlying type `int32_t`.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-0-10

If the bitwise operators ~ and << are applied to an operand with an underlying type of unsigned char or unsigned short, the result shall be immediately cast to the underlying type of the operand

Description

Rule Definition

If the bitwise operators ~ and << are applied to an operand with an underlying type of unsigned char or unsigned short, the result shall be immediately cast to the underlying type of the operand.

Message in Report

If the bitwise operators ~ and << are applied to an operand with an underlying type of unsigned char or unsigned short, the result shall be immediately cast to the underlying type of the operand.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-0-11

The plain char type shall only be used for the storage and use of character values

Description

Rule Definition

The plain char type shall only be used for the storage and use of character values.

Polyspace Implementation

The checker raises a violation when a value of signed or unsigned integer type is implicitly converted to the plain char type.

Message in Report

The plain char type shall only be used for the storage and use of character values.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2015a

MISRA C++:2008 Rule 5-0-12

Signed char and unsigned char type shall only be used for the storage and use of numeric values

Description

Rule Definition

Signed char and unsigned char type shall only be used for the storage and use of numeric values.

Message in Report

Signed char and unsigned char type shall only be used for the storage and use of numeric values.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2015a

MISRA C++:2008 Rule 5-0-13

The condition of an if-statement and the condition of an iteration- statement shall have type bool

Description

Rule Definition

The condition of an if-statement and the condition of an iteration- statement shall have type bool.

Message in Report

The condition of an if-statement and the condition of an iteration- statement shall have type bool.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-0-14

The first operand of a conditional-operator shall have type bool

Description

Rule Definition

The first operand of a conditional-operator shall have type bool.

Message in Report

The first operand of a conditional-operator shall have type bool.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-0-15

Array indexing shall be the only form of pointer arithmetic

Description

Rule Definition

Array indexing shall be the only form of pointer arithmetic.

Polyspace Implementation

The checker flags:

- Arithmetic operations on all pointers, for instance `p+I`, `I+p` and `p-I`, where `p` is a pointer and `I` an integer..
- Array indexing on nonarray pointers.

Message in Report

Array indexing shall be the only form of pointer arithmetic.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-0-17

Subtraction between pointers shall only be applied to pointers that address elements of the same array

Description

Rule Definition

Subtraction between pointers shall only be applied to pointers that address elements of the same array.

Polyspace Implementation

Use Bug Finder for this checker. The rule checker performs the same checks as `Subtraction or comparison between pointers to different arrays`. Code Prover can fail to detect some violations.

Message in Report

Subtraction between pointers shall only be applied to pointers that address elements of the same array.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-0-18

>, >=, <, <= shall not be applied to objects of pointer type, except where they point to the same array

Description

Rule Definition

>, >=, <, <= shall not be applied to objects of pointer type, except where they point to the same array.

Polyspace Implementation

Use Bug Finder for this checker. The rule checker performs the same checks as `Subtraction or comparison between pointers to different arrays`. Code Prover can fail to detect some violations.

The checker ignores casts when showing the violation on relational operator use with pointers types.

Message in Report

>, >=, <, <= shall not be applied to objects of pointer type, except where they point to the same array.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-0-19

The declaration of objects shall contain no more than two levels of pointer indirection

Description

Rule Definition

The declaration of objects shall contain no more than two levels of pointer indirection.

Message in Report

The declaration of objects shall contain no more than two levels of pointer indirection.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-0-20

Non-constant operands to a binary bitwise operator shall have the same underlying type

Description

Rule Definition

Non-constant operands to a binary bitwise operator shall have the same underlying type.

Message in Report

Non-constant operands to a binary bitwise operator shall have the same underlying type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-0-21

Bitwise operators shall only be applied to operands of unsigned underlying type

Description

Rule Definition

Bitwise operators shall only be applied to operands of unsigned underlying type.

Message in Report

Bitwise operators shall only be applied to operands of unsigned underlying type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-2-1

Each operand of a logical && or || shall be a postfix-expression

Description

Rule Definition

Each operand of a logical && or || shall be a postfix-expression.

Polyspace Implementation

During preprocessing, violations of this rule are detected on the expressions in `#if` directives.

The checker allows exceptions on associativity (a && b && c), (a || b || c).

Message in Report

Each operand of a logical && or || shall be a postfix-expression.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-2-2

A pointer to a virtual base class shall only be cast to a pointer to a derived class by means of dynamic_cast

Description

Rule Definition

A pointer to a virtual base class shall only be cast to a pointer to a derived class by means of dynamic_cast.

Message in Report

A pointer to a virtual base class shall only be cast to a pointer to a derived class by means of dynamic_cast.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-2-3

Casts from a base class to a derived class should not be performed on polymorphic types

Description

Rule Definition

Casts from a base class to a derived class should not be performed on polymorphic types.

Message in Report

Casts from a base class to a derived class should not be performed on polymorphic types.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Advisory

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-2-4

C-style casts (other than void casts) and functional notation casts (other than explicit constructor calls) shall not be used

Description

Rule Definition

C-style casts (other than void casts) and functional notation casts (other than explicit constructor calls) shall not be used.

Message in Report

C-style casts (other than void casts) and functional notation casts (other than explicit constructor calls) shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-2-5

A cast shall not remove any const or volatile qualification from the type of a pointer or reference

Description

Rule Definition

A cast shall not remove any const or volatile qualification from the type of a pointer or reference.

Message in Report

A cast shall not remove any const or volatile qualification from the type of a pointer or reference.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-2-6

A cast shall not convert a pointer to a function to any other pointer type, including a pointer to function type

Description

Rule Definition

A cast shall not convert a pointer to a function to any other pointer type, including a pointer to function type.

Message in Report

A cast shall not convert a pointer to a function to any other pointer type, including a pointer to function type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-2-7

An object with pointer type shall not be converted to an unrelated pointer type, either directly or indirectly

Description

Rule Definition

An object with pointer type shall not be converted to an unrelated pointer type, either directly or indirectly.

Polyspace Implementation

The checker flags all pointer conversions including between a pointer to a `struct` object and a pointer to the first member of the same `struct` type.

Indirect conversions from a pointer to non-pointer type are not detected.

Message in Report

An object with pointer type shall not be converted to an unrelated pointer type, either directly or indirectly.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-2-8

An object with integer type or pointer to void type shall not be converted to an object with pointer type

Description

Rule Definition

An object with integer type or pointer to void type shall not be converted to an object with pointer type.

Polyspace Implementation

The checker allows an exception on zero constants.

Objects with pointer type include objects with pointer-to-function type.

Message in Report

An object with integer type or pointer to void type shall not be converted to an object with pointer type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-2-9

A cast should not convert a pointer type to an integral type

Description

Rule Definition

A cast should not convert a pointer type to an integral type.

Message in Report

A cast should not convert a pointer type to an integral type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Advisory

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-2-10

The increment (++) and decrement (--) operators should not be mixed with other operators in an expression

Description

Rule Definition

The increment (++) and decrement (--) operators should not be mixed with other operators in an expression.

Message in Report

The increment (++) and decrement (--) operators should not be mixed with other operators in an expression.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Advisory

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-2-11

The comma operator, && operator and the || operator shall not be overloaded

Description

Rule Definition

The comma operator, && operator and the || operator shall not be overloaded.

Message in Report

The comma operator, && operator and the || operator shall not be overloaded.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-2-12

An identifier with array type passed as a function argument shall not decay to a pointer

Description

Rule Definition

An identifier with array type passed as a function argument shall not decay to a pointer.

Message in Report

An identifier with array type passed as a function argument shall not decay to a pointer.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-3-1

Each operand of the ! operator, the logical && or the logical || operators shall have type bool

Description

Rule Definition

Each operand of the ! operator, the logical && or the logical || operators shall have type bool.

Message in Report

Each operand of the ! operator, the logical && or the logical || operators shall have type bool.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-3-2

The unary minus operator shall not be applied to an expression whose underlying type is unsigned

Description

Rule Definition

The unary minus operator shall not be applied to an expression whose underlying type is unsigned.

Message in Report

The unary minus operator shall not be applied to an expression whose underlying type is unsigned.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-3-3

The unary & operator shall not be overloaded

Description

Rule Definition

The unary & operator shall not be overloaded.

Message in Report

The unary & operator shall not be overloaded.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-3-4

Evaluation of the operand to the sizeof operator shall not contain side effects

Description

Rule Definition

Evaluation of the operand to the sizeof operator shall not contain side effects.

Polyspace Implementation

The checker does not show a warning on volatile accesses and function calls

Message in Report

Evaluation of the operand to the sizeof operator shall not contain side effects.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-8-1

The right hand operand of a shift operator shall lie between zero and one less than the width in bits of the underlying type of the left hand operand

Description

Rule Definition

The right hand operand of a shift operator shall lie between zero and one less than the width in bits of the underlying type of the left hand operand.

Message in Report

The right hand operand of a shift operator shall lie between zero and one less than the width in bits of the underlying type of the left hand operand.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-14-1

The right hand operand of a logical && or || operator shall not contain side effects

Description

Rule Definition

The right hand operand of a logical && or || operator shall not contain side effects.

Polyspace Implementation

The checker does not show a warning on volatile accesses and function calls.

Message in Report

The right hand operand of a logical && or || operator shall not contain side effects.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-18-1

The comma operator shall not be used

Description

Rule Definition

The comma operator shall not be used.

Message in Report

The comma operator shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 5-19-1

Evaluation of constant unsigned integer expressions should not lead to wrap-around

Description

Rule Definition

Evaluation of constant unsigned integer expressions should not lead to wrap-around.

Message in Report

Evaluation of constant unsigned integer expressions should not lead to wrap-around.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-2-1

Assignment operators shall not be used in sub-expressions

Description

Rule Definition

Assignment operators shall not be used in sub-expressions.

Message in Report

Assignment operators shall not be used in sub-expressions.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-2-2

Floating-point expressions shall not be directly or indirectly tested for equality or inequality

Description

Rule Definition

Floating-point expressions shall not be directly or indirectly tested for equality or inequality.

Polyspace Implementation

The checker detects the use of == or != with floating-point variables or expressions. The checker does not detect indirectly testing of equality, for instance, using the <= operator.

Message in Report

Floating-point expressions shall not be directly or indirectly tested for equality or inequality.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-2-3

Before preprocessing, a null statement shall only occur on a line by itself; it may be followed by a comment, provided that the first character following the null statement is a white - space character

Description

Rule Definition

Before preprocessing, a null statement shall only occur on a line by itself; it may be followed by a comment, provided that the first character following the null statement is a white - space character.

Polyspace Implementation

The checker considers a null statement as a line where the first character excluding comments is a semicolon. The checker flags situations where:

- Comments appear before the semicolon.

  For instance:

  ```
  /* wait for pin */ ;
  ```

- Comments appear immediately after the semicolon without a white space in between.

  For instance:

  ```
  ;// wait for pin
  ```

The checker also shows a violation when a second statement appears on the same line following the null statement.

For instance:

```
; count++;
```

Message in Report

Before preprocessing, a null statement shall only occur on a line by itself; it may be followed by a comment, provided that the first character following the null statement is a white - space character.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-3-1

The statement forming the body of a switch, while, do while or for statement shall be a compound statement

Description

Rule Definition

The statement forming the body of a switch, while, do ... while or for statement shall be a compound statement.

Message in Report

The statement forming the body of a switch, while, do ... while or for statement shall be a compound statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-4-1

An if (condition) construct shall be followed by a compound statement The else keyword shall be followed by either a compound statement, or another if statement

Description

Rule Definition

An if (condition) construct shall be followed by a compound statement. The else keyword shall be followed by either a compound statement, or another if statement.

Message in Report

An if (condition) construct shall be followed by a compound statement. The else keyword shall be followed by either a compound statement, or another if statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-4-2

All if else if constructs shall be terminated with an else clause

Description

Rule Definition

All if ... else if constructs shall be terminated with an else clause.

Message in Report

All if ... else if constructs shall be terminated with an else clause.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-4-3

A switch statement shall be a well-formed switch statement

Description

Rule Definition

A switch statement shall be a well-formed switch statement.

Polyspace Implementation

The checker flags these situations:

- A statement occurs between the `switch` statement and the first `case` statement.

  For instance:

  ```
  switch(ch) {
    int temp;
    case 1:
      break;
    default:
      break;
  }
  ```
- A label or a jump statement such as `goto` or `return` occurs in the `switch` block.
- A variable is declared in a `case` statement (outside any block).

  For instance:

  ```
  switch(ch) {
    case 1:
      int temp;
      break;
    default:
      break;
  }
  ```

Message in Report

A switch statement shall be a well-formed switch statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-4-4

A switch-label shall only be used when the most closely-enclosing compound statement is the body of a switch statement

Description

Rule Definition

A switch-label shall only be used when the most closely-enclosing compound statement is the body of a switch statement.

Message in Report

A switch-label shall only be used when the most closely-enclosing compound statement is the body of a switch statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-4-5

An unconditional throw or break statement shall terminate every non - empty switch-clause

Description

Rule Definition

An unconditional throw or break statement shall terminate every non - empty switch-clause.

Message in Report

An unconditional throw or break statement shall terminate every non - empty switch-clause.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-4-6

The final clause of a switch statement shall be the default-clause

Description

Rule Definition

The final clause of a switch statement shall be the default-clause.

Polyspace Implementation

The checker detects `switch` statements that do not have a final `default` clause.

The checker does not raise a violation if the `switch` variable is an `enum` with finite number of values and you have a `case` clause for each value. For instance:

```
enum Colours { RED, BLUE, GREEN } colour;

switch ( colour ) {
      case RED:
        break;
      case BLUE:
        break;
      case GREEN:
        break;
}
```

Message in Report

The final clause of a switch statement shall be the default-clause.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-4-7

The condition of a switch statement shall not have bool type

Description

Rule Definition

The condition of a switch statement shall not have bool type.

Message in Report

The condition of a switch statement shall not have bool type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-4-8

Every switch statement shall have at least one case-clause

Description

Rule Definition

Every switch statement shall have at least one case-clause.

Message in Report

Every switch statement shall have at least one case-clause.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-5-1

A for loop shall contain a single loop-counter which shall not have floating type

Description

Rule Definition

A for loop shall contain a single loop-counter which shall not have floating type.

Polyspace Implementation

The checker flags these situations:

- The `for` loop index has a floating point type.
- More than one loop counter is incremented in the `for` loop increment statement.

  For instance:

  ```
  for(i=0, j=0; i<10 && j < 10;i++, j++) {}
  ```
- A loop counter is not incremented in the `for` loop increment statement.

  For instance:

  ```
  for(i=0; i<10;) {}
  ```

  Even if you increment the loop counter in the loop body, the checker still raises a violation.

Message in Report

A for loop shall contain a single loop-counter which shall not have floating type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-5-2

If loop-counter is not modified by -- or ++, then, within condition, the loop-counter shall only be used as an operand to <=, <, > or >=

Description

Rule Definition

If loop-counter is not modified by -- or ++, then, within condition, the loop-counter shall only be used as an operand to <=, <, > or >=.

Message in Report

If loop-counter is not modified by -- or ++, then, within condition, the loop-counter shall only be used as an operand to <=, <, > or >=.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-5-3

The loop-counter shall not be modified within condition or statement

Description

Rule Definition

The loop-counter shall not be modified within condition or statement.

Rationale

The `for` loop has a specific syntax for modifying the loop counter. A code reviewer expects modification using that syntax. Modifying the loop counter elsewhere can make the code harder to review.

Polyspace Implementation

The checker flags modification of a `for` loop counter in the loop body or the loop condition (the condition that is checked to see if the loop must be terminated).

Message in Report

The loop-counter shall not be modified within condition or statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-5-4

The loop-counter shall be modified by one of: --, ++, -=n, or +=n ; where n remains constant for the duration of the loop

Description

Rule Definition

The loop-counter shall be modified by one of: --, ++, -=n, or +=n ; where n remains constant for the duration of the loop.

Message in Report

The loop-counter shall be modified by one of: --, ++, -=n, or +=n ; where n remains constant for the duration of the loop.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-5-5

A loop-control-variable other than the loop-counter shall not be modified within condition or expression

Description

Rule Definition

A loop-control-variable other than the loop-counter shall not be modified within condition or expression.

Message in Report

A loop-control-variable other than the loop-counter shall not be modified within condition or expression.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-5-6

A loop-control-variable other than the loop-counter which is modified in statement shall have type bool

Description

Rule Definition

A loop-control-variable other than the loop-counter which is modified in statement shall have type bool.

Message in Report

A loop-control-variable other than the loop-counter which is modified in statement shall have type bool.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-6-1

Any label referenced by a goto statement shall be declared in the same block, or in a block enclosing the goto statement

Description

Rule Definition

Any label referenced by a goto statement shall be declared in the same block, or in a block enclosing the goto statement.

Message in Report

Any label referenced by a goto statement shall be declared in the same block, or in a block enclosing the goto statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-6-2

The goto statement shall jump to a label declared later in the same function body

Description

Rule Definition

The goto statement shall jump to a label declared later in the same function body.

Message in Report

The goto statement shall jump to a label declared later in the same function body.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-6-3

The continue statement shall only be used within a well-formed for loop

Description

Rule Definition

The continue statement shall only be used within a well-formed for loop.

Polyspace Implementation

The checker flags the use of `continue` statements in:

- `for` loops that are not well-formed, that is, loops that violate rules 6-5-x.
- `while` loops.

Message in Report

The continue statement shall only be used within a well-formed for loop.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-6-4

For any iteration statement there shall be no more than one break or goto statement used for loop termination

Description

Rule Definition

For any iteration statement there shall be no more than one break or goto statement used for loop termination.

Message in Report

For any iteration statement there shall be no more than one break or goto statement used for loop termination.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 6-6-5

A function shall have a single point of exit at the end of the function

Description

Rule Definition

A function shall have a single point of exit at the end of the function.

Rationale

This rule requires that a `return` statement must occur as the last statement in the function body. Otherwise, the following issues can occur:

- Code following a `return` statement can be unintentionally omitted.
- If a function that modifies some of its arguments has early `return` statements, when reading the code, it is not immediately clear which modifications actually occur.

Polyspace Implementation

The checker flags these situations:

- A function has more than one `return` statement.
- A non-`void` function has one `return` statement only but the `return` statement is not the last statement in the function.

A `void` function need not have a `return` statement. If a `return` statement exists, it need not be the last statement in the function.

Message in Report

A function shall have a single point of exit at the end of the function.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 7-1-1

A variable which is not modified shall be const qualified

Description

Rule Definition

A variable which is not modified shall be const qualified.

Polyspace Implementation

The checker flags function parameters or local variables that are not const-qualified but never modified in the function body. Function parameters of integer, float, enum and boolean types are not flagged.

If a variable is passed to another function by reference or pointers, the checker assumes that the variable can be modified. These variables are not flagged.

Message in Report

A variable which is not modified shall be const qualified.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarations
Category: Required

See Also

Introduced in R2018a

MISRA C++:2008 Rule 7-1-2

A pointer or reference parameter in a function shall be declared as pointer to const or reference to const if the corresponding object is not modified

Description

Rule Definition

A pointer or reference parameter in a function shall be declared as pointer to const or reference to const if the corresponding object is not modified.

Polyspace Implementation

The checker flags pointers where the underlying object is not const-qualified but never modified in the function body.

If a variable is passed to another function by reference or pointers, the checker assumes that the variable can be modified. Pointers that point to these variables are not flagged.

Message in Report

A pointer or reference parameter in a function shall be declared as pointer to const or reference to const if the corresponding object is not modified.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarations
Category: Required

See Also

Introduced in R2018a

MISRA C++:2008 Rule 7-3-1

The global namespace shall only contain main, namespace declarations and extern "C" declarations

Description

Rule Definition

The global namespace shall only contain main, namespace declarations and extern "C" declarations.

Message in Report

The global namespace shall only contain main, namespace declarations and extern "C" declarations.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarations
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 7-3-2

The identifier main shall not be used for a function other than the global function main

Description

Rule Definition

The identifier main shall not be used for a function other than the global function main.

Message in Report

The identifier main shall not be used for a function other than the global function main.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarations
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 7-3-3

There shall be no unnamed namespaces in header files

Description

Rule Definition

There shall be no unnamed namespaces in header files.

Message in Report

There shall be no unnamed namespaces in header files.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarations
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 7-3-4

using-directives shall not be used

Description

Rule Definition

using-directives shall not be used.

Message in Report

using-directives shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarations
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 7-3-5

Multiple declarations for an identifier in the same namespace shall not straddle a using-declaration for that identifier

Description

Rule Definition

Multiple declarations for an identifier in the same namespace shall not straddle a using-declaration for that identifier.

Message in Report

Multiple declarations for an identifier in the same namespace shall not straddle a using-declaration for that identifier.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarations
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 7-3-6

using-directives and using-declarations (excluding class scope or function scope using-declarations) shall not be used in header files

Description

Rule Definition

using-directives and using-declarations (excluding class scope or function scope using-declarations) shall not be used in header files.

Message in Report

using-directives and using-declarations (excluding class scope or function scope using-declarations) shall not be used in header files.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarations
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 7-4-2

Assembler instructions shall only be introduced using the asm declaration

Description

Rule Definition

Assembler instructions shall only be introduced using the asm declaration.

Message in Report

Assembler instructions shall only be introduced using the asm declaration.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarations
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 7-4-3

Assembly language shall be encapsulated and isolated

Description

Rule Definition

Assembly language shall be encapsulated and isolated.

Polyspace Implementation

The checker flags `asm` statements unless they are encapsulated in a function call.

For instance, the noncompliant `asm` statement below is in regular C code while the compliant `asm` statement is encapsulated in a call to the function `Delay`.

```
void Delay ( void )
  {
    asm( "NOP");//Compliant
  }
void fn (void)
  {
    DoSomething();
    Delay();// Assembler is encapsulated
    DoSomething();
    asm("NOP"); //Noncompliant
    DoSomething();
  }
```

Message in Report

Assembly language shall be encapsulated and isolated.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarations
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 7-5-1

A function shall not return a reference or a pointer to an automatic variable (including parameters), defined within the function

Description

Rule Definition

A function shall not return a reference or a pointer to an automatic variable (including parameters), defined within the function.

Message in Report

A function shall not return a reference or a pointer to an automatic variable (including parameters), defined within the function.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarations
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 7-5-2

The address of an object with automatic storage shall not be assigned to another object that may persist after the first object has ceased to exist

Description

Rule Definition

The address of an object with automatic storage shall not be assigned to another object that may persist after the first object has ceased to exist.

Polyspace Implementation

The checker flags situations where the address of a local variable is assigned to a pointer defined at global scope.

The checker does not raise violations of this rule if :

- A function returns the address of a local variable. This situation is covered by `MISRA C++:2008 Rule 7-5-1`.
- The address of a variable defined at block scope is assigned to a pointer that is defined with greater scope (but not global scope).

  For instance:

  ```
  void foobar ( void )
   {
     char * ptr;
     {
       char var;
       ptr = &var;
     }
   }
  ```

  Only if the pointer is defined at global scope is the issue detected. For instance, the rule checker flags the issue here:

```
char * ptr;
void foobar ( void )
  {
      char var;
      ptr = &var;
  }
```

Message in Report

The address of an object with automatic storage shall not be assigned to another object that may persist after the first object has ceased to exist.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarations
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 7-5-3

A function shall not return a reference or a pointer to a parameter that is passed by reference or const reference

Description

Rule Definition

A function shall not return a reference or a pointer to a parameter that is passed by reference or const reference.

Message in Report

A function shall not return a reference or a pointer to a parameter that is passed by reference or const reference.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarations
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 7-5-4

Functions should not call themselves, either directly or indirectly

Description

Rule Definition

Functions should not call themselves, either directly or indirectly.

Message in Report

Functions should not call themselves, either directly or indirectly.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarations
Category: Advisory

See Also

Introduced in R2013b

MISRA C++:2008 Rule 8-0-1

An init-declarator-list or a member-declarator-list shall consist of a single init-declarator or member-declarator respectively

Description

Rule Definition

An init-declarator-list or a member-declarator-list shall consist of a single init-declarator or member-declarator respectively.

Message in Report

An init-declarator-list or a member-declarator-list shall consist of a single init-declarator or member-declarator respectively.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarators
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 8-3-1

Parameters in an overriding virtual function shall either use the same default arguments as the function they override, or else shall not specify any default arguments

Description

Rule Definition

Parameters in an overriding virtual function shall either use the same default arguments as the function they override, or else shall not specify any default arguments.

Message in Report

Parameters in an overriding virtual function shall either use the same default arguments as the function they override, or else shall not specify any default arguments.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarators
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 8-4-1

Functions shall not be defined using the ellipsis notation

Description

Rule Definition

Functions shall not be defined using the ellipsis notation.

Message in Report

Functions shall not be defined using the ellipsis notation.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarators
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 8-4-2

The identifiers used for the parameters in a re-declaration of a function shall be identical to those in the declaration

Description

Rule Definition

The identifiers used for the parameters in a re-declaration of a function shall be identical to those in the declaration.

Polyspace Implementation

The checker detects mismatch in parameter names between:

- A function declaration and the corresponding definition.
- Two declarations of a function, provided they occur in the same file.

  If the declarations occur in different files, the checker does not raise a violation for mismatch in parameter names. Redeclarations in different files are forbidden by `MISRA C++:2008 Rule 3-2-3`.

Message in Report

The identifiers used for the parameters in a re-declaration of a function shall be identical to those in the declaration.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarators
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 8-4-3

All exit paths from a function with non- void return type shall have an explicit return statement with an expression

Description

Rule Definition

All exit paths from a function with non- void return type shall have an explicit return statement with an expression.

Message in Report

All exit paths from a function with non- void return type shall have an explicit return statement with an expression.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarators
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 8-4-4

A function identifier shall either be used to call the function or it shall be preceded by &

Description

Rule Definition

A function identifier shall either be used to call the function or it shall be preceded by &.

Message in Report

A function identifier shall either be used to call the function or it shall be preceded by &.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarators
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 8-5-1

All variables shall have a defined value before they are used

Description

Rule Definition

All variables shall have a defined value before they are used.

Message in Report

All variables shall have a defined value before they are used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarators
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 8-5-2

Braces shall be used to indicate and match the structure in the non- zero initialization of arrays and structures

Description

Rule Definition

Braces shall be used to indicate and match the structure in the non- zero initialization of arrays and structures.

Message in Report

Braces shall be used to indicate and match the structure in the non- zero initialization of arrays and structures.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarators
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 8-5-3

In an enumerator list, the = construct shall not be used to explicitly initialize members other than the first, unless all items are explicitly initialized

Description

Rule Definition

In an enumerator list, the = construct shall not be used to explicitly initialize members other than the first, unless all items are explicitly initialized.

Message in Report

In an enumerator list, the = construct shall not be used to explicitly initialize members other than the first, unless all items are explicitly initialized.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarators
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 9-3-1

const member functions shall not return non-const pointers or references to class-data

Description

Rule Definition

const member functions shall not return non-const pointers or references to class-data.

Polyspace Implementation

The checker flags a rule violation only if a `const` member function returns a non-`const` pointer or reference to a nonstatic data member. The rule does not apply to static data members.

Message in Report

const member functions shall not return non-const pointers or references to class-data.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Classes
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 9-3-2

Member functions shall not return non-const handles to class-data

Description

Rule Definition

Member functions shall not return non-const handles to class-data.

Polyspace Implementation

The checker flags a rule violation only if a member function returns a non-`const` pointer or reference to a nonstatic data member. The rule does not apply to static data members.

Message in Report

Member functions shall not return non-const handles to class-data.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Classes
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 9-3-3

If a member function can be made static then it shall be made static, otherwise if it can be made const then it shall be made const

Description

Rule Definition

If a member function can be made static then it shall be made static, otherwise if it can be made const then it shall be made const.

Polyspace Implementation

The checker flags member functions that are not declared static but do not access a data member of the class. Such a function can be potentially declared static.

The checker flags member functions that are not declared const but do not modify a data member of the class. Such a function can be potentially declared const.

Message in Report

If a member function can be made static then it shall be made static, otherwise if it can be made const then it shall be made const.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Classes
Category: Required

See Also

Introduced in R2018a

MISRA C++:2008 Rule 9-5-1

Unions shall not be used

Description

Rule Definition

Unions shall not be used.

Message in Report

Unions shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Classes
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 9-6-2

Bit-fields shall be either bool type or an explicitly unsigned or signed integral type

Description

Rule Definition

Bit-fields shall be either bool type or an explicitly unsigned or signed integral type.

Message in Report

Bit-fields shall be either bool type or an explicitly unsigned or signed integral type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Classes
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 9-6-3

Bit-fields shall not have enum type

Description

Rule Definition

Bit-fields shall not have enum type.

Message in Report

Bit-fields shall not have enum type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Classes
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 9-6-4

Named bit-fields with signed integer type shall have a length of more than one bit

Description

Rule Definition

Named bit-fields with signed integer type shall have a length of more than one bit.

Message in Report

Named bit-fields with signed integer type shall have a length of more than one bit.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Classes
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 10-1-1

Classes should not be derived from virtual bases

Description

Rule Definition

Classes should not be derived from virtual bases.

Rationale

The use of virtual bases can lead to many confusing behaviors.

For instance, in an inheritance hierarchy involving a virtual base, the most derived class calls the constructor of the virtual base. Intermediate calls to the virtual base constructor are ignored.

Message in Report

Classes should not be derived from virtual bases.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of Virtual Bases

```
class Base {};
class Intermediate: public virtual Base {}; //Noncompliant
class Final: public Intermediate {};
```

In this example, the rule checker raises a violation when the `Intermediate` class is derived from the class `Base` with the `virtual` keyword.

The following behavior can be a potential source of confusion. When you create an object of type `Final`, the constructor of `Final` directly calls the constructor of `Base`. Any call to the `Base` constructor from the `Intermediate` constructor are ignored. You might see unexpected results if you do not take into account this behavior.

Check Information

Group: Derived Classes
Category: Advisory

See Also

`MISRA C++:2008 Rule 10-1-2`

Introduced in R2013b

MISRA C++:2008 Rule 10-1-2

A base class shall only be declared virtual if it is used in a diamond hierarchy

Description

Rule Definition

A base class shall only be declared virtual if it is used in a diamond hierarchy.

Rationale

This rule is less restrictive than `MISRA C++:2008 Rule 10-1-1`. Rule 10-1-1 forbids the use of a virtual base anywhere in your code because a virtual base can lead to potentially confusing behavior.

Rule 10-1-2 allows the use of virtual bases in the one situation where they are useful, that is, as a common base class in diamond hierarchies.

For instance, the following diamond hierarchy violates rule 10-1-1 but not rule 10-1-2.

```
class Base {};
class Intermediate1: public virtual Base {};
class Intermediate2: public virtual Base {};
class Final: public Intermediate1, public Intermediate2 {};
```

Message in Report

A base class shall only be declared virtual if it is used in a diamond hierarchy.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Derived Classes
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 10-1-3

An accessible base class shall not be both virtual and non-virtual in the same hierarchy

Description

Rule Definition

An accessible base class shall not be both virtual and non-virtual in the same hierarchy.

Rationale

The checker flags situations where the same class is inherited as a virtual base class and a non-virtual base class in the same derived class. These situations defeat the purpose of virtual inheritance and causes multiple copies of the base class sub-object in the derived class object.

Message in Report

An accessible base class shall not be both virtual and non-virtual in the same hierarchy.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Base Class Both Virtual and Non-Virtual in Same Hierarchy

```
class Base {};
class Intermediate1: virtual public Base {};
class Intermediate2: virtual public Base {};
```

```
class Intermediate3: public Base {};
class Final: public Intermediate1, Intermediate2, Intermediate3 {}; //Noncompliant
```

In this example, the class `Base` is inherited in `Final` both as a virtual and non-virtual base class. The `Final` object contains at least two copies of a `Base` sub-object.

Check Information

Group: Derived Classes
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 10-2-1

All accessible entity names within a multiple inheritance hierarchy should be unique

Description

Rule Definition

All accessible entity names within a multiple inheritance hierarchy should be unique.

Polyspace Implementation

The checker flags data members from different classes with conflicting names if the same class derives from these classes. For instance:

```
class B1
  {
    public:
      int count;
      void foo ( );
  };
class B2
  {
    public:
      int count;
      void foo ( );
  };

class D : public B1, public B2
  {
    public:
      void Bar ( )
      {
        ++B1::count;
        B1::foo ( );
      }
  };
```

If the data member access in the derived class is ambiguous, the analysis reports this issue as a compilation error and not a coding rule violation. For instance, a compilation error occurs in the preceding example if the class `D` is rewritten as:

```
class D : public B1, public B2
  {
    public:
      void Bar ( )
      {
        ++count;      // Is that B1::count or B2::count?
        foo ( );      // Is that B1::foo() or B2::foo()?
      }
  };
```

The checker does not check for conflicts between entities of different kinds, for instance, member functions against data members.

Message in Report

All accessible entity names within a multiple inheritance hierarchy should be unique.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Derived Classes
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 10-3-1

There shall be no more than one definition of each virtual function on each path through the inheritance hierarchy

Description

Rule Definition

There shall be no more than one definition of each virtual function on each path through the inheritance hierarchy.

Rationale

The checker flags virtual member functions that have multiple definitions on the same path in an inheritance hierarchy. If a function is defined multiple times, it can be ambiguous which implementation is used in a given function call.

Polyspace Implementation

The checker also raises a violation if a base class member function is redefined in the derived class without the `virtual` keyword.

Message in Report

There shall be no more than one definition of each virtual function on each path through the inheritance hierarchy.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Virtual Function Redefined in Derived Class

```
class Base {
    public:
      virtual void foo() {
     }
};

class Intermediate1: public virtual Base {
    public:
      virtual void foo() { //Noncompliant
      }
};

class Intermediate2: public virtual Base {
    public:
       void bar() {
          foo();  // Calls Base::foo()
      }
};

class Final: public Intermediate1, public Intermediate2 {
};

void main() {
    Intermediate2 intermediate2Obj;
    intermediate2Obj.bar(); // Calls Base::foo()
    Final finalObj;
    finalObj.bar(); //Calls Intermediate1::foo()
                    //but you might expect Base::foo()
}
```

In this example, the `virtual` function `foo` is defined in the base class `Base` and also in the derived class `Intermediate1`.

A potential source of confusion can be the following. The class `Final` derives from `Intermediate1` and also derives from `Base` through another path using `Intermediate2`.

- When an `Intermediate2` object calls the function `bar` that calls the function `foo`, the implementation of `foo` in `Base` is called. An `Intermediate2` object does not know of the implementation in `Intermediate1`.
- However, when a `Final` object calls the same function `bar` that calls the function `foo`, the implementation of `foo` in `Intermediate1` is called because of dominance of the more derived class.

You might see unexpected results if you do not take this behavior into account.

To prevent this issue, declare a function as pure virtual in the base class. For instance, you can declare the class `Base` as follows:

```
class Base {
    public:
      virtual void foo()=0;
};

void Base::foo() {
      //You can still define Base::foo()
}
```

Check Information

Group: Derived Classes
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 10-3-2

Each overriding virtual function shall be declared with the virtual keyword

Description

Rule Definition

Each overriding virtual function shall be declared with the virtual keyword.

Message in Report

Each overriding virtual function shall be declared with the virtual keyword.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Derived Classes
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 10-3-3

A virtual function shall only be overridden by a pure virtual function if it is itself declared as pure virtual

Description

Rule Definition

A virtual function shall only be overridden by a pure virtual function if it is itself declared as pure virtual.

Message in Report

A virtual function shall only be overridden by a pure virtual function if it is itself declared as pure virtual.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Derived Classes
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 11-0-1

Member data in non- POD class types shall be private

Description

Rule Definition

Member data in non- POD class types shall be private.

Message in Report

Member data in non- POD class types shall be private.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Member Access Control
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 12-1-1

An object's dynamic type shall not be used from the body of its constructor or destructor

Description

Rule Definition

An object's dynamic type shall not be used from the body of its constructor or destructor.

Message in Report

An object's dynamic type shall not be used from the body of its constructor or destructor.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Special Member Functions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 12-1-2

All constructors of a class should explicitly call a constructor for all of its immediate base classes and all virtual base classes

Description

Rule Definition

All constructors of a class should explicitly call a constructor for all of its immediate base classes and all virtual base classes.

Message in Report

All constructors of a class should explicitly call a constructor for all of its immediate base classes and all virtual base classes.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Special Member Functions
Category: Advisory

See Also

Introduced in R2013b

MISRA C++:2008 Rule 12-1-3

All constructors that are callable with a single argument of fundamental type shall be declared explicit

Description

Rule Definition

All constructors that are callable with a single argument of fundamental type shall be declared explicit.

Message in Report

All constructors that are callable with a single argument of fundamental type shall be declared explicit.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Special Member Functions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 12-8-1

A copy constructor shall only initialize its base classes and the non- static members of the class of which it is a member

Description

Rule Definition

A copy constructor shall only initialize its base classes and the non- static members of the class of which it is a member.

Message in Report

A copy constructor shall only initialize its base classes and the non- static members of the class of which it is a member.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Special Member Functions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 12-8-2

The copy assignment operator shall be declared protected or private in an abstract class

Description

Rule Definition

The copy assignment operator shall be declared protected or private in an abstract class.

Message in Report

The copy assignment operator shall be declared protected or private in an abstract class.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Special Member Functions
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 14-5-2

A copy constructor shall be declared when there is a template constructor with a single parameter that is a generic parameter

Description

Rule Definition

A copy constructor shall be declared when there is a template constructor with a single parameter that is a generic parameter.

Message in Report

A copy constructor shall be declared when there is a template constructor with a single parameter that is a generic parameter.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Templates
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 14-5-3

A copy assignment operator shall be declared when there is a template assignment operator with a parameter that is a generic parameter

Description

Rule Definition

A copy assignment operator shall be declared when there is a template assignment operator with a parameter that is a generic parameter.

Message in Report

A copy assignment operator shall be declared when there is a template assignment operator with a parameter that is a generic parameter.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Templates
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 14-6-1

In a class template with a dependent base, any name that may be found in that dependent base shall be referred to using a qualified-id or this->

Description

Rule Definition

In a class template with a dependent base, any name that may be found in that dependent base shall be referred to using a qualified-id or this->

Message in Report

In a class template with a dependent base, any name that may be found in that dependent base shall be referred to using a qualified-id or this->

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Templates
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 14-6-2

The function chosen by overload resolution shall resolve to a function declared previously in the translation unit

Description

Rule Definition

The function chosen by overload resolution shall resolve to a function declared previously in the translation unit.

Message in Report

The function chosen by overload resolution shall resolve to a function declared previously in the translation unit.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Templates
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 14-7-3

All partial and explicit specializations for a template shall be declared in the same file as the declaration of their primary template

Description

Rule Definition

All partial and explicit specializations for a template shall be declared in the same file as the declaration of their primary template.

Message in Report

All partial and explicit specializations for a template shall be declared in the same file as the declaration of their primary template.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Templates
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 14-8-1

Overloaded function templates shall not be explicitly specialized

Description

Rule Definition

Overloaded function templates shall not be explicitly specialized.

Polyspace Implementation

The checker first checks within file scope to find overloads. The checker later looks for call to a specialized template function later. As a result, the checker flags all specializations of overloaded templates even if overloading occurs after the call.

Message in Report

Overloaded function templates shall not be explicitly specialized.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Templates
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 14-8-2

The viable function set for a function call should either contain no function specializations, or only contain function specializations

Description

Rule Definition

The viable function set for a function call should either contain no function specializations, or only contain function specializations.

Message in Report

The viable function set for a function call should either contain no function specializations, or only contain function specializations.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Templates
Category: Advisory

See Also

Introduced in R2013b

MISRA C++:2008 Rule 15-0-2

An exception object should not have pointer type

Description

Rule Definition

An exception object should not have pointer type.

Polyspace Implementation

The checker raises a violation if a `throw` statement throws an exception of pointer type.

The checker does not raise a violation if a NULL pointer is thrown as exception. Throwing a NULL pointer is forbidden by `MISRA C++:2008 Rule 15-1-2`.

Message in Report

An exception object should not have pointer type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling
Category: Advisory

See Also

Introduced in R2013b

MISRA C++:2008 Rule 15-0-3

Control shall not be transferred into a try or catch block using a goto or a switch statement

Description

Rule Definition

Control shall not be transferred into a try or catch block using a goto or a switch statement.

Message in Report

Control shall not be transferred into a try or catch block using a goto or a switch statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 15-1-2

NULL shall not be thrown explicitly

Description

Rule Definition

NULL shall not be thrown explicitly.

Message in Report

NULL shall not be thrown explicitly.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 15-1-3

An empty throw (throw;) shall only be used in the compound- statement of a catch handler

Description

Rule Definition

An empty throw (throw;) shall only be used in the compound- statement of a catch handler.

Message in Report

An empty throw (throw;) shall only be used in the compound- statement of a catch handler.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 15-3-2

There should be at least one exception handler to catch all otherwise unhandled exceptions

Description

Rule Definition

There should be at least one exception handler to catch all otherwise unhandled exceptions.

Polyspace Implementation

The checker shows a violation if there is no `try`/`catch` in the `main` function or the `catch` does not handle all exceptions (with ellipsis `...`). The rule is not checked if a `main` function does not exist.

The checker does not determine if an exception of an unhandled type actually propagates to `main`.

Bug Finder and Code Prover check this coding rule differently. The analyses can produce different results.

Message in Report

There should be at least one exception handler to catch all otherwise unhandled exceptions.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling
Category: Advisory

See Also

Introduced in R2013b

MISRA C++:2008 Rule 15-3-3

Handlers of a function-try-block implementation of a class constructor or destructor shall not reference non-static members from this class or its bases

Description

Rule Definition

Handlers of a function-try-block implementation of a class constructor or destructor shall not reference non-static members from this class or its bases.

Message in Report

Handlers of a function-try-block implementation of a class constructor or destructor shall not reference non-static members from this class or its bases.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 15-3-5

A class type exception shall always be caught by reference

Description

Rule Definition

A class type exception shall always be caught by reference.

Message in Report

A class type exception shall always be caught by reference.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 15-3-6

Where multiple handlers are provided in a single try-catch statement or function-try-block for a derived class and some or all of its bases, the handlers shall be ordered most-derived to base class

Description

Rule Definition

Where multiple handlers are provided in a single try-catch statement or function-try-block for a derived class and some or all of its bases, the handlers shall be ordered most-derived to base class.

Message in Report

Where multiple handlers are provided in a single try-catch statement or function-try-block for a derived class and some or all of its bases, the handlers shall be ordered most-derived to base class.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 15-3-7

Where multiple handlers are provided in a single try-catch statement or function-try-block, any ellipsis (catch-all) handler shall occur last

Description

Rule Definition

Where multiple handlers are provided in a single try-catch statement or function-try-block, any ellipsis (catch-all) handler shall occur last.

Message in Report

Where multiple handlers are provided in a single try-catch statement or function-try-block, any ellipsis (catch-all) handler shall occur last.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 15-4-1

If a function is declared with an exception-specification, then all declarations of the same function (in other translation units) shall be declared with the same set of type-ids

Description

Rule Definition

If a function is declared with an exception-specification, then all declarations of the same function (in other translation units) shall be declared with the same set of type-ids.

Message in Report

If a function is declared with an exception-specification, then all declarations of the same function (in other translation units) shall be declared with the same set of type-ids.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 15-5-1

A class destructor shall not exit with an exception

Description

Rule Definition

A class destructor shall not exit with an exception.

Polyspace Implementation

The checker flags exceptions thrown in the body of the destructor. If the destructor calls another function, the checker does not detect if that function throws an exception.

The checker does not detect these situations:

- A `catch` statement does not catch exceptions of all types that are thrown.

  The checker considers the presence of a `catch` statement corresponding to a `try` block as indication that an exception is caught.
- `throw` statements inside `catch` blocks

Message in Report

A class destructor shall not exit with an exception.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling

Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 15-5-2

Where a function's declaration includes an exception-specification, the function shall only be capable of throwing exceptions of the indicated type(s)

Description

Rule Definition

Where a function's declaration includes an exception-specification, the function shall only be capable of throwing exceptions of the indicated type(s).

Polyspace Implementation

The checker flags situations where the data type of the exception thrown does not match the exception type listed in the function specification.

For instance:

```
void goo ( ) throw ( Exception )
  {
    throw 21; // Non-compliant - int is not listed
  }
```

The checker limits detection to `throw` statements that are in the body of the function. If the function calls another function, the checker does not detect if the called function throws an exception.

The checker does not detect `throw` statements inside `catch` blocks.

Message in Report

Where a function's declaration includes an exception-specification, the function shall only be capable of throwing exceptions of the indicated type(s).

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 15-5-3

The terminate() function shall not be called implicitly

Description

Rule Definition

The terminate() function shall not be called implicitly.

Polyspace Implementation

The checker flags these situations when the terminate() function can be called implicitly:

- An exception escapes uncaught. This also violates `MISRA C++:2008 Rule 15-3-2`. For instance:
  - Before an exception is caught, it escapes through another function that throws an uncaught exception. For instance, a catch statement or exception handler invokes a copy constructor that throws an uncaught exception.
  - A throw expression with no operand rethrows an uncaught exception.
- A class destructor throws an exception. This also violates `MISRA C++:2008 Rule 15-5-1`.

Message in Report

The terminate() function shall not be called implicitly.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling
Category: Required

See Also

Introduced in R2018a

MISRA C++:2008 Rule 16-0-1

#include directives in a file shall only be preceded by other preprocessor directives or comments

Description

Rule Definition

#include directives in a file shall only be preceded by other preprocessor directives or comments.

Message in Report

#include directives in a file shall only be preceded by other preprocessor directives or comments.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-0-2

Macros shall only be #define 'd or #undef 'd in the global namespace

Description

Rule Definition

Macros shall only be #define 'd or #undef 'd in the global namespace.

Message in Report

Macros shall only be #define 'd or #undef 'd in the global namespace.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-0-3

#undef shall not be used

Description

Rule Definition

#undef shall not be used.

Message in Report

#undef shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-0-4

Function-like macros shall not be defined

Description

Rule Definition

Function-like macros shall not be defined.

Message in Report

Function-like macros shall not be defined.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-0-5

Arguments to a function-like macro shall not contain tokens that look like preprocessing directives

Description

Rule Definition

Arguments to a function-like macro shall not contain tokens that look like preprocessing directives.

Message in Report

Arguments to a function-like macro shall not contain tokens that look like preprocessing directives.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-0-6

In the definition of a function-like macro, each instance of a parameter shall be enclosed in parentheses, unless it is used as the operand of # or ##

Description

Rule Definition

In the definition of a function-like macro, each instance of a parameter shall be enclosed in parentheses, unless it is used as the operand of # or ##.

Message in Report

In the definition of a function-like macro, each instance of a parameter shall be enclosed in parentheses, unless it is used as the operand of # or ##.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-0-7

Undefined macro identifiers shall not be used in #if or #elif preprocessor directives, except as operands to the defined operator

Description

Rule Definition

Undefined macro identifiers shall not be used in #if or #elif preprocessor directives, except as operands to the defined operator.

Message in Report

Undefined macro identifiers shall not be used in #if or #elif preprocessor directives, except as operands to the defined operator.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-0-8

If the # token appears as the first token on a line, then it shall be immediately followed by a preprocessing token

Description

Rule Definition

If the # token appears as the first token on a line, then it shall be immediately followed by a preprocessing token.

Message in Report

If the # token appears as the first token on a line, then it shall be immediately followed by a preprocessing token.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-1-1

The defined preprocessor operator shall only be used in one of the two standard forms

Description

Rule Definition

The defined preprocessor operator shall only be used in one of the two standard forms.

Message in Report

The defined preprocessor operator shall only be used in one of the two standard forms.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-1-2

All #else, #elif and #endif preprocessor directives shall reside in the same file as the #if or #ifdef directive to which they are related

Description

Rule Definition

All #else, #elif and #endif preprocessor directives shall reside in the same file as the #if or #ifdef directive to which they are related.

Message in Report

All #else, #elif and #endif preprocessor directives shall reside in the same file as the #if or #ifdef directive to which they are related.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-2-1

The preprocessor shall only be used for file inclusion and include guards

Description

Rule Definition

The preprocessor shall only be used for file inclusion and include guards.

Polyspace Implementation

The checker flags `#ifdef` and `#define` statements in files that are not include files.

Message in Report

The preprocessor shall only be used for file inclusion and include guards.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-2-2

C++ macros shall only be used for: include guards, type qualifiers, or storage class specifiers

Description

Rule Definition

C++ macros shall only be used for: include guards, type qualifiers, or storage class specifiers.

Polyspace Implementation

The checker flags `#define` statements where the macros expand to something other than include guards, type qualifiers or storage class specifiers such as `static`, `inline`, `volatile`, `auto`, `register` and `const`.

Message in Report

C++ macros shall only be used for: include guards, type qualifiers, or storage class specifiers.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-2-3

Include guards shall be provided

Description

Rule Definition

Include guards shall be provided.

Polyspace Implementation

The checker raises a violation if a header file does not contain an include guard.

For instance, this code uses an include guard for the `#define` and `#include` statements and does not violate the rule:

```
// Contents of a header file
#ifndef FILE_H

#define FILE_H
#include "libFile.h"

#endif
```

Message in Report

Include guards shall be provided.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-2-4

The ', ", /* or // characters shall not occur in a header file name

Description

Rule Definition

The ', ", / or // characters shall not occur in a header file name.*

Message in Report

The ', ", /* or // characters shall not occur in a header file name.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-2-5

The \ character should not occur in a header file name

Description

Rule Definition

The \ character should not occur in a header file name.

Message in Report

The \ character should not occur in a header file name.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Advisory

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-2-6

The #include directive shall be followed by either a <filename> or "filename" sequence

Description

Rule Definition

The #include directive shall be followed by either a <filename> or "filename" sequence.

Message in Report

The #include directive shall be followed by either a <filename> or "filename" sequence.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-3-1

There shall be at most one occurrence of the # or ## operators in a single macro definition

Description

Rule Definition

There shall be at most one occurrence of the # or ## operators in a single macro definition.

Message in Report

There shall be at most one occurrence of the # or ## operators in a single macro definition.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-3-2

The # and ## operators should not be used

Description

Rule Definition

The # and ## operators should not be used.

Message in Report

The # and ## operators should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Advisory

See Also

Introduced in R2013b

MISRA C++:2008 Rule 16-6-1

All uses of the #pragma directive shall be documented

Description

Rule Definition

All uses of the #pragma directive shall be documented.

Polyspace Implementation

To check this rule, you must list the pragmas that are allowed in source files by using the option `Allowed pragmas (-allowed-pragmas)`. If Polyspace finds a pragma not in the allowed pragma list, a violation is raised. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Message in Report

All uses of the #pragma directive shall be documented.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives
Category: Document

See Also

Introduced in R2016b

MISRA C++:2008 Rule 17-0-1

Reserved identifiers, macros and functions in the standard library shall not be defined, redefined or undefined

Description

Rule Definition

Reserved identifiers, macros and functions in the standard library shall not be defined, redefined or undefined.

Message in Report

Reserved identifiers, macros and functions in the standard library shall not be defined, redefined or undefined.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Library Introduction
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 17-0-2

The names of standard library macros and objects shall not be reused

Description

Rule Definition

The names of standard library macros and objects shall not be reused.

Message in Report

The names of standard library macros and objects shall not be reused.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Library Introduction
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 17-0-3

The names of standard library functions shall not be overridden

Description

Rule Definition

The names of standard library functions shall not be overridden.

Message in Report

The names of standard library functions shall not be overridden.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Library Introduction
Category: Required

See Also

Introduced in R2018a

MISRA C++:2008 Rule 17-0-5

The setjmp macro and the longjmp function shall not be used

Description

Rule Definition

The setjmp macro and the longjmp function shall not be used.

Message in Report

The setjmp macro and the longjmp function shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Library Introduction
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 18-0-1

The C library shall not be used

Description

Rule Definition

The C library shall not be used.

Message in Report

The C library shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Language Support Library
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 18-0-2

The library functions atof, atoi and atol from library <cstdlib> shall not be used

Description

Rule Definition

The library functions atof, atoi and atol from library <cstdlib> shall not be used.

Message in Report

The library functions atof, atoi and atol from library <cstdlib> shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Language Support Library
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 18-0-3

The library functions abort, exit, getenv and system from library <cstdlib> shall not be used

Description

Rule Definition

The library functions abort, exit, getenv and system from library <cstdlib> shall not be used.

Message in Report

The library functions abort, exit, getenv and system from library <cstdlib> shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Language Support Library
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 18-0-4

The time handling functions of library <ctime> shall not be used

Description

Rule Definition

The time handling functions of library <ctime> shall not be used.

Message in Report

The time handling functions of library <ctime> shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Language Support Library
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 18-0-5

The unbounded functions of library <cstring> shall not be used

Description

Rule Definition

The unbounded functions of library <cstring> shall not be used.

Message in Report

The unbounded functions of library <cstring> shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Language Support Library
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 18-2-1

The macro offsetof shall not be used

Description

Rule Definition

The macro offsetof shall not be used.

Message in Report

The macro offsetof shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Language Support Library
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 18-4-1

Dynamic heap memory allocation shall not be used

Description

Rule Definition

Dynamic heap memory allocation shall not be used.

Message in Report

Dynamic heap memory allocation shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Language Support Library
Category: Required

See Also

Introduced in R2013b

MISRA C++:2008 Rule 18-7-1

The signal handling facilities of <csignal> shall not be used

Description

Rule Definition

The signal handling facilities of <csignal> shall not be used.

Rationale

Signal handling functions such as `signal` contains undefined and implementation-specific behavior.

You have to be very careful when using `signal` to avoid these behaviors.

Message in Report

The signal handling facilities of <csignal> shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Language Support Library
Category: Required

See Also

`Function called from signal handler not asynchronous-safe` | `Return from computational exception signal handler` | `Shared data access within signal handler` | `Signal call in multithreaded program`

Introduced in R2013b

MISRA C++:2008 Rule 19-3-1

The error indicator errno shall not be used

Description

Rule Definition

The error indicator errno shall not be used.

Rationale

Observing this rule encourages the good practice of not relying on `errno` to check error conditions.

Checking `errno` is not sufficient to guarantee absence of errors. Functions such as `fopen` might not set `errno` on error conditions. Often, you have to check the return value of such functions for error conditions.

Message in Report

The error indicator errno shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of `errno`

```
#include <cstdlib>
#include <cerrno>
```

```
void func (const char* str) {
    errno = 0;  // Noncompliant
    int i = atoi(str);
    if(errno != 0) { // Noncompliant
        //Handle Error
    }
}
```

The use of `errno` violates this rule. The function `atoi` is not required to set `errno` if the input string cannot be converted to an integer. Checking `errno` later does not safeguard against possible failures in conversion.

Check Information

Group: Diagnostic Library
Category: Required

See Also

`Misuse of errno` | `Misuse of errno in a signal handler`

Introduced in R2013b

MISRA C++:2008 Rule 27-0-1

The stream input/output library <cstdio> shall not be used

Description

Rule Definition

The stream input/output library <cstdio> shall not be used.

Rationale

Functions in `cstdio` such as `gets`, `fgetpos`, `fopen`, `ftell`, etc. have unspecified, undefined and implementation-defined behavior.

For instance:

- The `gets` function:

  ```
  char * gets ( char * buf );
  ```

  does not check if the number of characters provided at the standard input exceeds the buffer `buf`. The function can have unexpected behavior when the input exceeds the buffer.
- The `fopen` function has implementation-specific behavior related to whether it sets `errno` on errors or whether it accepts additional characters following the standard mode specifiers.

Message in Report

The stream input/output library <cstdio> shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of `gets`

```
#include <cstdio>

void func() {
 char array[10];
 gets(array);
}
```

The use of `gets` violates this rule.

Check Information

Group: Input/output Library
Category: Required

See Also

Introduced in R2013b

4

CERT C Rules and Recommendations

Acknowledgement

Rule 01. Preprocessor (PRE)

CERT C: Rule PRE30-C

Do not create a universal character name through concatenation

Description

Rule Definition

Do not create a universal character name through concatenation.

Examples

Universal character name from token concatenation

Description

Universal character name from token concatenation occurs when two preprocessing tokens joined with a ## operator create a universal character name. A universal character name begins with `\u` or `\U` followed by hexadecimal digits. It represents a character not found in the basic character set.

For instance, you form the character `\u0401` by joining two tokens:

```
#define assign(uc1, uc2, val) uc1##uc2 = val
...
assign(\u04, 01, 4);
```

Risk

The C11 Standard (Sec. 5.1.1.2) states that if a universal character name is formed by token concatenation, the behavior is undefined.

Fix

Use the universal character name directly instead of producing it through token concatenation.

Example - Universal Character Name from Token Concatenation

```
#define assign(uc1, uc2, val) uc1##uc2 = val

int func(void) {
    int \u0401 = 0;
    assign(\u04, 01, 4);
    return \u0401;
}
```

In this example, the `assign` macro, when expanded, joins the two tokens `\u04` and `01` to form the universal character name `\u0401`.

Correction — Use Universal Character Name Directly

One possible correction is to use the universal character name `\u0401` directly. The correction redefines the `assign` macro so that it does not join tokens.

```
#define assign(ucn, val) ucn = val

int func(void) {
    int \u0401 = 0;
    assign(\u0401, 4);
    return \u0401;
}
```

Check Information

Group: Rule 01. Preprocessor (PRE)

See Also

External Websites

PRE30-C

Introduced in R2019a

CERT C: Rule PRE31-C

Avoid side effects in arguments to unsafe macros

Description

Rule Definition

Avoid side effects in arguments to unsafe macros.

Examples

Side effect in arguments to unsafe macro

Description

Side effect in arguments to unsafe macro occurs when you call an unsafe macro with an expression that has a side effect.

- *Unsafe macro*: When expanded, an unsafe macro evaluates its arguments multiple times or does not evaluate its argument at all.

  For instance, the `ABS` macro evaluates its argument `x` twice.

  ```
  #define ABS(x) (((x) < 0) ? -(x) : (x))
  ```

- *Side effect*: When evaluated, an expression with a side effect modifies at least one of the variables in the expression.

  For instance, `++n` modifies `n`, but `n+1` does not modify `n`.

  The checker does not consider side effects in nested macros. The checker also does not consider function calls or volatile variable access as side effects.

Risk

If you call an unsafe macro with an expression that has a side effect, the expression is evaluated multiple times or not evaluated at all. The side effect can occur multiple times or not occur at all, causing unexpected behavior.

For instance, in the call `MACRO(++n)`, you expect only one increment of the variable `n`. If `MACRO` is an unsafe macro, the increment happens more than once or does not happen at all.

The checker flags expressions with side effects in the `assert` macro because the `assert` macro is disabled in non-debug mode. To compile in non-debug mode, you define the `NDEBUG` macro during compilation. For instance, in GCC, you use the flag `-DNDEBUG`.

Fix

Evaluate the expression with a side effect in a separate statement, and then use the result as a macro argument.

For instance, instead of:

```
MACRO(++n);
```

perform the operation in two steps:

```
++n;
MACRO(n);
```

Alternatively, use an inline function instead of a macro. Pass the expression with side effect as argument to the inline function.

The checker considers modifications of a local variable defined only in the block scope of a macro body as a side effect. This defect cannot happen since the variable is visible only in the macro body. If you see a defect of this kind, ignore the defect.

Example - Macro Argument with Side Effects

```
#define ABS(x) (((x) < 0) ? -(x) : (x))

void func(int n) {
  /* Validate that n is within the desired range */
  int m = ABS(++n);
```

```
  /* ... */
}
```

In this example, the ABS macro evaluates its argument twice. The second evaluation can result in an unintended increment.

Correction — Separate Evaluation of Expression from Macro Usage

One possible correction is to first perform the increment, and then pass the result to the macro.

```
#define ABS(x) (((x) < 0) ? -(x) : (x))

void func(int n) {
  /* Validate that n is within the desired range */
  ++n;
  int m = ABS(n);

  /* ... */
}
```

Correction — Evaluate Expression in Inline Function

Another possible correction is to evaluate the expression in an inline function.

```
static inline int iabs(int x) {
  return (((x) < 0) ? -(x) : (x));
}

void func(int n) {
  /* Validate that n is within the desired range */

int m = iabs(++n);

  /* ... */
}
```

Check Information

Group: Rule 01. Preprocessor (PRE)

See Also

External Websites

PRE31-C

Introduced in R2019a

CERT C: Rule PRE32-C

Do not use preprocessor directives in invocations of function-like macros

Description

Rule Definition

Do not use preprocessor directives in invocations of function-like macros.

Examples

Preprocessor directive in macro argument

Description

Preprocessor directive in macro argument occurs when you use a preprocessor directive in the argument to a function-like macro or a function that might be implemented as a function-like macro.

For instance, a `#ifdef` statement occurs in the argument to a `memcpy` function. The `memcpy` function might be implemented as a macro.

```
memcpy(dest, src,
    #ifdef PLATFORM1
      12
    #else
      24
    #endif
  );
```

The checker flags similar usage in `printf` and `assert`, which can also be implemented as macros.

Risk

During preprocessing, a function-like macro call is replaced by the macro body and the parameters are replaced by the arguments to the macro call (argument substitution). Suppose a macro `min()` is defined as follows.

```
#define min(X, Y)  ((X) < (Y) ? (X) : (Y))
```

When you call `min(1,2)`, it is replaced by the body `((X) < (Y) ? (X) : (Y))`. `X` and `Y` are replaced by 1 and 2.

According to the C11 Standard (Sec. 6.10.3), if the list of arguments to a function-like macro itself has preprocessing directives, the argument substitution during preprocessing is undefined.

Fix

To ensure that the argument substitution happens in an unambiguous manner, use the preprocessor directives outside the function-like macro.

For instance, to execute `memcpy` with different arguments based on a `#ifdef` directive, call `memcpy` multiple times within the `#ifdef` directive branches.

```
#ifdef PLATFORM1
    memcpy(dest, src, 12);
#else
    memcpy(dest, src, 24);
#endif
```

Example - Directives in Function-Like Macros

```
#include <stdio.h>

#define print(A) printf(#A)

void func(void) {
    print(
#ifdef SW
          "Message 1"
#else
          "Message 2"
#endif
         );
}
```

In this example, the preprocessor directives `#ifdef` and `#endif` occur in the argument to the function-like macro `print()`.

Correction — Use Directives Outside Macro

One possible correction is to use the function-like macro multiple times in the branches of the `#ifdef` directive.

```
#include <stdio.h>

#define print(A) printf(#A)

void func(void) {
#ifdef SW
        print("Message 1");
#else
        print("Message 2");
#endif
}
```

Check Information

Group: Rule 01. Preprocessor (PRE)

See Also

External Websites

PRE32-C

Introduced in R2019a

Rule 02. Declarations and Initialization (DCL)

CERT C: Rule DCL30-C

Declare objects with appropriate storage durations

Description

Rule Definition

Declare objects with appropriate storage durations.

Examples

Pointer or reference to stack variable leaving scope

Description

Pointer or reference to stack variable leaving scope occurs when a pointer or reference to a local variable leaves the scope of the variable. For instance:

- A function returns a pointer to a local variable.
- A function performs the assignment `globPtr = &locVar`. `globPtr` is a global pointer variable and `locVar` is a local variable.
- A function performs the assignment `*paramPtr = &locVar`. `paramPtr` is a function parameter that is, for instance, an `int**` pointer and `locVar` is a local `int` variable.
- A C++ method performs the assignment `memPtr = &locVar`. `memPtr` is a pointer data member of the class the method belongs to. `locVar` is a variable local to the method.

The defect also applies to memory allocated using the `alloca` function. The defect does not apply to static, local variables.

Risk

Local variables are allocated an address on the stack. Once the scope of a local variable ends, this address is available for reuse. Using this address to access the local variable value outside the variable scope can cause unexpected behavior.

If a pointer to a local variable leaves the scope of the variable, Polyspace Bug Finder highlights the defect. The defect appears even if you do not use the address stored in the pointer. For maintainable code, it is a good practice to not allow the pointer to leave the variable scope. Even if you do not use the address in the pointer now, someone else using your function can use the address, causing undefined behavior.

Fix

Do not allow a pointer or reference to a local variable to leave the variable scope.

Example - Pointer to Local Variable Returned from Function

```
void func2(int *ptr) {
    *ptr = 0;
}

int* func1(void) {
    int ret = 0;
    return &ret ;
}
void main(void) {
    int* ptr = func1() ;
    func2(ptr) ;
}
```

In this example, `func1` returns a pointer to local variable `ret`.

In `main`, `ptr` points to the address of the local variable. When `ptr` is accessed in `func2`, the access is illegal because the scope of `ret` is limited to `func1`,

Check Information

Group: Rule 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL30-C

Introduced in R2019a

CERT C: Rule DCL31-C

Declare identifiers before using them

Description

Rule Definition

Declare identifiers before using them.

Examples

Types not explicitly specified

Description

The rule checker flags situations where a function parameter or return type is not explicitly specified. To enable checking of this rule, use the value `c90` for the option `C standard version (-c-version)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

In some circumstances, you can omit types from the C90 standard. In those cases, the `int` type is implicitly specified. However, the omission of an explicit type can lead to confusion. For example, in the declaration `extern void foo (char c, const k);`, the type of `k` is `const int`, but you might expect `const char`.

You might be using an implicit type in:

- Object declarations
- Parameter declarations
- Member declarations
- `typedef` declarations

- Function return types

Example - Implicit Types

```
static foo(int a);  /* Non compliant */
static void bar(void);      /* Compliant */
```

In this example, the rule is violated because the return type of `foo` is implicit.

Implicit function declaration

Description

The issue occurs when you call a function before you declare or define it.

Risk

An implicit declaration occurs when you call a function before declaring or defining it. When you declare a function explicitly before calling it, the compiler can match the argument and return types with the parameter types in the declaration. If an implicit declaration occurs, the compiler makes assumptions about the argument and return types. For instance, it assumes a return type of `int`. The assumptions might not agree with what you expect and cause undesired type conversions.

Example - Function Not Declared Before Call

```
#include <math.h>

extern double power3 (double val, int exponent);
int getChoice(void);

double func() {
    double res;
    int ch = getChoice();
    if(ch == 0) {
        res = power(2.0, 10);    /* Non-compliant */
    }
    else if( ch==1) {
        res = power2(2.0, 10);   /* Non-compliant */
    }
    else {
        res = power3(2.0, 10);   /* Compliant */
        return res;
```

```
    }
}

double power2 (double val, int exponent) {
    return (pow(val, exponent));
}
```

In this example, the rule is violated when a function that is not declared is called in the code. Even if a function definition exists later in the code, the rule violation occurs.

The rule is not violated when the function is declared before it is called in the code. If the function definition exists in another file and is available only during the link phase, you can declare the function in one of the following ways:

- Declare the function with the `extern` keyword in the current file.
- Declare the function in a header file and include the header file in the current file.

Check Information

Group: Rule 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL31-C

Introduced in R2019a

CERT C: Rule DCL36-C

Do not declare an identifier with conflicting linkage classifications

Description

Rule Definition

Do not declare an identifier with conflicting linkage classifications.

Examples

Inconsistent use of `static` and `extern` in object declarations

Description

The issue occurs when you do not use the `static` storage class specifier consistently in all declarations of object and functions that have internal linkage.

The rule checker detects situations where:

- The same object is declared multiple times with different storage specifiers.
- The same function is declared and defined with different storage specifiers.

Risk

If you do not use the `static` specifier consistently in all declarations of objects with internal linkage, you might declare the same object with external and internal linkage.

In this situation, the linkage follows the earlier specification that is visible (C99 Standard, Section 6.2.2). For instance, if the earlier specification indicates internal linkage, the object has internal linkage even though the latter specification indicates external linkage. If you notice the latter specification alone, you might expect otherwise.

Example - Linkage Conflict Between Variable Declarations

```
static int foo = 0;
extern int foo;         /* Non-compliant */

extern int hhh;
static int hhh;         /* Non-compliant */
```

In this example, the first line defines `foo` with internal linkage. The first line is compliant because the example uses the `static` keyword. The second line does not use `static` in the declaration, so the declaration is noncompliant. By comparison, the third line declares `hhh` with an `extern` keyword creating external linkage. The fourth line declares `hhh` with internal linkage, but this declaration conflicts with the first declaration of `hhh`.

Correction — Consistent `static` and `extern` Use

One possible correction is to use `static` and `extern` consistently:

```
static int foo = 0;
static int foo;

extern int hhh;
extern int hhh;
```

Example - Linkage Conflict Between Function Declaration and Definition

```
static int fee(void);  /* Compliant - declaration: internal linkage */
int fee(void){         /* Non-compliant */
  return 1;
}

static int ggg(void);  /* Compliant - declaration: internal linkage */
extern int ggg(void){  /* Non-compliant */
  return 1 + x;
}
```

This example shows two internal linkage violations. Because `fee` and `ggg` have internal linkage, you must use a `static` class specifier to be compliant with MISRA.

Check Information

Group: Rule 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL36-C

Introduced in R2019a

CERT C: Rule DCL37-C

Do not declare or define a reserved identifier

Description

Rule Definition

Do not declare or define a reserved identifier.

Examples

Defining and undefining reserved identifiers or macros

Description

The issue occurs when you use `#define` and `#undef` on a reserved identifier or reserved macro name.

Risk

Reserved identifiers and reserved macro names are intended for use by the implementation. Removing or changing the meaning of a reserved macro can result in undefined behavior. This rule applies to the following:

- Identifiers or macro names beginning with an underscore
- Identifiers in file scope described in the C Standard Library (ISO/IEC 9899:1999, Section 7, "Library")
- Macro names described in the C Standard Library as being defined in a standard header (ISO/IEC 9899:1999, Section 7, "Library").

Example - Defining or Undefining Reserved Identifiers

```
#undef __LINE__               /* Non-compliant - begins with _ */
#define _Guard_H 1            /* Non-compliant - begins with _ */
```

```
#undef _ BUILTIN_sqrt        /* Non-compliant - implementation may
                                * use _BUILTIN_sqrt for other purposes,
                                * e.g. generating a sqrt instruction */
#define defined               /* Non-compliant - reserved identifier */
#define errno my_errno        /* Non-compliant - library identifier */
#define isneg(x) ( (x) < 0 )  /* Compliant - rule doesn't include
                                * future library directions   */
```

Declaring a reserved identifier or macro name

Description

The issue occurs when you declare a reserved identifer or macro name.

If you define a macro name that corresponds to a standard library macro, object, or function, Polyspace considers this a violation of the rule.

The rule considers tentative definitions as definitions.

Risk

The Standard allows implementations to treat reserved identifiers specially. If you reuse reserved identifiers, you can cause undefined behavior.

Check Information

Group: Rule 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL37-C

Introduced in R2019a

CERT C: Rule DCL38-C

Use the correct syntax when declaring a flexible array member

Description

Rule Definition

Use the correct syntax when declaring a flexible array member.

Examples

Incorrect syntax of flexible array member size

Description

Incorrect syntax of flexible array member size occurs when you do not use the standard C syntax to define a structure with a flexible array member.

Since C99, you can define a flexible array member with an unspecified size. For instance, `desc` is a flexible array member in this example:

```
struct record {
    size_t len;
    double desc[];
};
```

Prior to C99, you might have used compiler-specific methods to define flexible arrays. For instance, you used arrays of size one or zero:

```
struct record {
    size_t len;
    double desc[0];
};
```

This usage is not compliant with the C standards following C99.

Risk

If you define flexible array members by using size zero or one, your implementation is compiler-dependent. For compilers that do not recognize the syntax, an `int` array of size one has buffer for one `int` variable. If you try to write beyond this buffer, you can run into issues stemming from array access out of bounds.

If you use the standard C syntax to define a flexible array member, your implementation is portable across all compilers conforming with the standard.

Fix

To implement a flexible array member in a structure, define an array of unspecified size. The structure must have one member besides the array and the array must be the last member of the structure.

Example - Flexible Array Member Defined with Size One

```
#include <stdlib.h>

struct flexArrayStruct {
  int num;
  int data[1];
};

unsigned int max_size = 100;

void func(unsigned int array_size) {
  if(array_size<= 0 || array_size > max_size)
      exit(1);
  /* Space is allocated for the struct */
  struct flexArrayStruct *structP
    = (struct flexArrayStruct *)
     malloc(sizeof(struct flexArrayStruct)
          + sizeof(int) * (array_size - 1));
  if (structP == NULL) {
    /* Handle malloc failure */
    exit(2);
  }

  structP->num = array_size;

  /*
   * Access data[] as if it had been allocated
```

```
   * as data[array_size].
   */
  for (unsigned int i = 0; i < array_size; ++i) {
    structP->data[i] = 1;
  }

  free(structP);
}
```

In this example, the flexible array member `data` is defined with a size value of one. Compilers that do not recognize this syntax treat `data` as a size-one array. The statement `structP->data[i] = 1;` can write to `data` beyond the first array member and cause out of bounds array issues.

Correction — Use Standard C Syntax to Define Flexible Array

Define flexible array members with unspecified size.

```
#include <stdlib.h>

struct flexArrayStruct{
  int num;
  int data[];
};

unsigned int max_size = 100;

void func(unsigned int array_size) {
  if(array_size<=0 || array_size > max_size)
      exit(1);

  /* Allocate space for structure */
  struct flexArrayStruct *structP
    = (struct flexArrayStruct *)
    malloc(sizeof(struct flexArrayStruct)
         + sizeof(int) * array_size);

  if (structP == NULL) {
    /* Handle malloc failure */
    exit(2);
  }

  structP->num = array_size;
```

```
  /*
   * Access data[] as if it had been allocated
   * as data[array_size].
   */
  for (unsigned int i = 0; i < array_size; ++i) {
    structP->data[i] = 1;
  }

  free(structP);
}
```

Check Information

Group: Rule 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL38-C

Introduced in R2019a

CERT C: Rule DCL39-C

Avoid information leakage in structure padding

Description

Rule Definition

Avoid information leakage in structure padding.

Examples

Information leak via structure padding

Description

Information leak via structure padding occurs when you do not initialize the padding data of a structure or union before passing it across a trust boundary. A compiler adds padding bytes to the structure or union to ensure a proper memory alignment of its members. The bit-fields of the storage units can also have padding bits.

Information leak via structure padding raises a defect when:

- You call an untrusted function with structure or union pointer type argument containing uninitialized padding data.

  All external functions are considered untrusted.
- You copy or assign a structure or union containing uninitialized padding data to an untrusted object.

  All external structure or union objects, the output parameters of all externally linked functions, and the return pointer of all external functions are considered untrusted objects.

Risk

The padding bytes of the passed structure or union might contain sensitive information that an untrusted source can access.

Fix

- Prevent the addition of padding bytes for memory alignment by using the `pack` pragma or attribute supported by your compiler.
- Explicitly declare and initialize padding bytes as fields within the structure or union.
- Explicitly declare and initialize bit-fields corresponding to padding bits, even if you use the `pack` pragma or attribute supported by your compiler.

Example - Structure with Padding Bytes Passed to External Function

```
#include <stddef.h>
#include <stdlib.h>
#include <string.h>

typedef struct s_padding
{
 /* Padding bytes may be introduced between
 * 'char c' and 'int i'
 */
        char c;
    int i;

/*Padding bits may be introduced around the bit-fields
* even if you use "#pragma pack" (Windows) or
* __attribute__((__packed__)) (GNU)*/

    unsigned int bf1:1;
    unsigned int bf2:2;
    unsigned char buffer[20];
} S_Padding ;



/* External function */
extern void copy_object(void *out, void *in, size_t s);

void func(void *out_buffer)
{
```

```
/*Padding bytes not initialized*/

    S_Padding s = {'A', 10, 1, 3, {}};
/*Structure passed to external function*/

    copy_object((void *)out_buffer, (void *)&s, sizeof(s));
}

void main(void)
{
    S_Padding s1;
    func(&s1);
}
```

In this example, structure `s1` can have padding bytes between the `char c` and `int i` members. The bit-fields of the storage units of the structure can also contain padding bits. The content of the padding bytes and bits is accessible to an untrusted source when `s1` is passed to `func`.

Correction — Use pack Pragma to Prevent Padding Bytes

One possible correction in Microsoft Visual Studiois to use `#pragma pack()` to prevent padding bytes between the structure members. To prevent padding bits in the bit-fields of `s1`, explicitly declare and initialize the bit-fields even if you use `#pragma pack()`.

```
 #include <stddef.h>
#include <stdlib.h>
#include <string.h>
#include <limits.h>

#define CHAR_BIT 8

#pragma pack(push, 1)

typedef struct s_padding
{
/*No Padding bytes when you use "#pragma pack" (Windows) or
* __attribute__((__packed__)) (GNU)*/
    char c;
    int i;
    unsigned int bf1:1;
    unsigned int bf2:2;
/* Padding bits explicitely declared */
    unsigned int bf_filler : sizeof(unsigned) * CHAR_BIT - 3;
```

```
    unsigned char buffer[20];
}

    S_Padding;

#pragma pack(pop)


/* External function */
extern void copy_object(void *out, void *in, size_t s);



void func(void *out_buffer)
{
    S_Padding s = {'A', 10, 1, 3, 0 /* padding bits */, {}};
    copy_object((void *)out_buffer, (void *)&s, sizeof(s));
}

void main(void)
{
    S_Padding s1;
    func(&s1);
}
```

Check Information

Group: Rule 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL39-C

Introduced in R2019a

CERT C: Rule DCL40-C

Do not create incompatible declarations of the same function or object

Description

Rule Definition

Do not create incompatible declarations of the same function or object.

Examples

Declaration mismatch

Description

Declaration mismatch occurs when a function or variable declaration does not match other instances of the function or variable.

Risk

When a mismatch occurs between two variable declarations in different compilation units, a typical linker follows an algorithm to pick one declaration for the variable. If you expect a variable declaration that is different from the one chosen by the linker, you can see unexpected results when the variable is used.

A similar issue can occur with mismatch in function declarations.

Fix

The fix depends on the type of declaration mismatch. If both declarations indeed refer to the same object, use the same declaration. If the declarations refer to different objects, change the names of the one of the variables. If you change a variable name, remember to make the change in all places that use the variable.

Sometimes, declaration mismatches can occur because the declarations are affected by previous preprocessing directives. For instance, a declaration occurs in a macro, and the

macro is defined on one inclusion path but undefined in another. These declaration mismatches can be tricky to debug. Identify the divergence between the two inclusion paths and fix the conflicting macro definitions.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Inconsistent Declarations in Two Files

file1.c

```
int foo(void) {
    return 1;
}
```

file2.c

```
double foo(void);

int bar(void) {
    return (int)foo();
}
```

In this example, *file1.c* declares `foo()` as returning an integer. In *file2.c*, `foo()` is declared as returning a double. This difference raises a defect on the second instance of `foo` in *file2*.

Correction — Align the Function Return Values

One possible correction is to change the function declarations so that they match. In this example, by changing the declaration of `foo` in *file2.c* to match *file1.c*, the defect is fixed.

file1.c

```
int foo(void) {
    return 1;
}
```

file2.c

```
int foo(void);

int bar(void) {
    return foo();
}
```

Example - Inconsistent Structure Alignment

test1.c

```
#include "square.h"
#include "circle.h"
struct aCircle circle;
struct aSquare square;

int main(){
    square.side=1;
    circle.radius=1;
    return 0;
}
```

test2.c

```
#include "circle.h"
#include "square.h"
struct aCircle circle;
struct aSquare square;

int main(){
    square.side=1;
    circle.radius=1;
    return 0;
}
```

circle.h

```
#pragma pack(1)

extern struct aCircle{
    int radius;
} circle;
```

square.h

```
extern struct aSquare {
    unsigned int side:1;
} square;
```

In this example, a declaration mismatch defect is raised on `square` in *square.h* because Polyspace infers that `square` in *square.h* does not have the same alignment as `square` in *test2.c*. This error occurs because the `#pragma pack(1)` statement in *circle.h* declares specific alignment. In *test2.c*, *circle.h* is included before *square.h*. Therefore, the `#pragma pack(1)` statement from *circle.h* is not reset to the default alignment after the `aCircle` structure. Because of this omission, *test2.c* infers that the `aSquare square` structure also has an alignment of `1` byte.

Correction — Close Packing Statements

One possible correction is to reset the structure alignment after the `aCircle` struct declaration. For the GNU or Microsoft Visual compilers, fix the defect by adding a `#pragma pack()` statement at the end of *circle.h*.

test1.c	*test2.c*

`#include "square.h"`
`#include "circle.h"`
`struct aCircle circle;`
`struct aSquare square;`
 	
`int main(){`
`  square.side=1;`
`  circle.radius=1;`
`  return 0;`
`}`
	`#include "circle.h"`
	`#include "square.h"`
	`struct aCircle circle;`
	`struct aSquare square;`
	
	`int main(){`
	`  square.side=1;`
	`  circle.radius=1;`
	`  return 0;`
	`}`

circle.h
 	
`#pragma pack(1)`
 	
`extern struct aCircle{`
`  int radius;`
`} circle;`
 	
`#pragma pack()`
	square.h
	
	`extern struct aSquare {`
	`  unsigned int side:1;`
	`} square;`

Other compilers require different `#pragma pack` syntax. For your syntax, see the documentation for your compiler.

Correction — Use the `Ignore pragma pack directives` Option

One possible correction is to add the `Ignore pragma pack directives` option to your Bug Finder analysis. If you want the structure alignment to change for each structure, and you do not want to see this **Declaration mismatch** defect, use this correction.

1. On the Configuration pane, select the **Advanced Settings** pane.
2. In the **Other** box, enter `-ignore-pragma-pack`.
3. Rerun your analysis.

   The **Declaration mismatch** defect is resolved.

Check Information

Group: Rule 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL40-C

Introduced in R2019a

CERT C: Rule DCL41-C

Do not declare variables inside a switch statement before the first case label

Description

Rule Definition

Do not declare variables inside a switch statement before the first case label.

Examples

`switch` statement not well-formed

Description

The issue occurs when your code has a `switch` statement that is not well-formed.

The coding rule checker raises a violation of this rule if a `switch` statement violates one of these:

- The `switch` label appears only at the outermost level of the body of the `switch` statement.
- The switch-clause ends with an unconditional `break` statement.
- The `switch` statement has a `default` label.
- The `default` label is either the first or last switch label of the `switch` statement.
- The `switch` statement has at least two switch-clauses.

.

Risk

The syntax for switch statements in C is not particularly rigorous and can allow complex, unstructured behavior. This rule and other rules impose a simple consistent structure on the `switch` statement.

Check Information

Group: Rule 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL41-C

Introduced in R2019a

Rule 03. Expressions (EXP))

CERT C: Rule EXP30-C

Do not depend on the order of evaluation for side effects

Description

Rule Definition

Do not depend on the order of evaluation for side effects.

Examples

Expression value depends on order of evaluation or of side effects

Description

The issue occurs when the value of an expression and its persistent side effects is not the same under all permitted evaluation orders.

An expression can have different values under the following conditions:

- The same variable is modified more than once in the expression, or is both read and written.
- The expression allows more than one order of evaluation.

Therefore, this rule forbids expressions where a variable is modified more than once and can cause different results under different orders of evaluation.

Risk

If an expression results in different values depending on the order of evaluation, its value becomes implementation-defined.

Example - Variable Modified More Than Once in Expression

```
int a[10], b[10];
#define COPY_ELEMENT(index) (a[(index)]=b[(index)])

void main () {
    int i=0, k=0;

    COPY_ELEMENT (k);         /* Compliant */
    COPY_ELEMENT (i++);       /* Noncompliant  */
}
```

In this example, the rule is violated by the statement `COPY_ELEMENT(i++)` because `i++` occurs twice and the order of evaluation of the two expressions is unspecified.

Example - Variable Modified and Used in Multiple Function Arguments

```
void f (unsigned int param1, unsigned int param2) {}

void main () {
    unsigned int i=0;
    f ( i++, i );                 /* Non-compliant */
}
```

In this example, the rule is violated because it is unspecified whether the operation `i++` occurs before or after the second argument is passed to `f`. The call `f(i++,i)` can translate to either `f(0,0)` or `f(0,1)`.

Check Information

Group: Rule 03. Expressions (EXP)

See Also

External Websites

EXP30-C

Introduced in R2019a

CERT C: Rule EXP32-C

Do not access a volatile object through a nonvolatile reference

Description

Rule Definition

Do not access a volatile object through a nonvolatile reference.

Examples

Cast to pointer that removes `const` or `volatile` qualification

Description

Polyspace flags both implicit and explicit conversions that violate this rule.

Risk

This rule forbids:

- Casts from a pointer to a `const` object to a pointer that does not point to a `const` object.
- Casts from a pointer to a `volatile` object to a pointer that does not point to a `volatile` object.

Such casts violate type qualification. For example, the `const` qualifier indicates the read-only status of an object. If a cast removes the qualifier, the object is no longer read-only.

Example - Casts That Remove Qualifiers

```
void foo(void) {

    /* Cast on simple type */
    unsigned short           x;
```

```
    unsigned short * const   cpi = &x;  /* const pointer */
    unsigned short * const  *pcpi;   /* pointer to const pointer */
    unsigned short **ppi;
    const unsigned short    *pci;    /* pointer to const */
    volatile unsigned short *pvi;    /* pointer to volatile  */
    unsigned short          *pi;

    pi = cpi;                        /* Compliant - no cast required */
    pi  = (unsigned short *)  pci;   /* Non-compliant */
    pi  = (unsigned short *)  pvi;   /* Non-compliant */
    ppi = (unsigned short **)pcpi;   /* Non-compliant */
}
```

In this example:

- The variables `pci` and `pcpi` have the `const` qualifier in their type. The rule is violated when the variables are cast to types that do not have the `const` qualifier.
- The variable `pvi` has a `volatile` qualifier in its type. The rule is violated when the variable is cast to a type that does not have the `volatile` qualifier.

Even though `cpi` has a `const` qualifier in its type, the rule is not violated in the statement `p=cpi;`. The assignment does not cause a type conversion because both `p` and `cpi` have type `unsigned short`.

Check Information

Group: Rule 03. Expressions (EXP)

See Also

External Websites

EXP32-C

Introduced in R2019a

CERT C: Rule EXP33-C

Do not read uninitialized memory

Description

Rule Definition

Do not read uninitialized memory.

Examples

Non-initialized pointer

Description

Non-initialized pointer occurs when a pointer is not assigned an address before dereference.

Risk

Unless a pointer is explicitly assigned an address, it points to an unpredictable location.

Fix

The fix depends on the root cause of the defect. For instance, you assigned an address to the pointer but the assignment is unreachable.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below. It is a good practice to initialize a pointer to NULL when declaring the pointer.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Non-initialized pointer error

```
#include <stdlib.h>

int* assign_pointer(int* prev)
{
    int j = 42;
    int* pi;

    if (prev == NULL)
      {
        pi = (int*)malloc(sizeof(int));
        if (pi == NULL) return NULL;
      }

    *pi = j;
    /* Defect: Writing to uninitialized pointer */

    return pi;
}
```

If `prev` is not `NULL`, the pointer `pi` is not assigned an address. However, `pi` is dereferenced on every execution paths, irrespective of whether `prev` is `NULL` or not.

Correction — Initialize Pointer on Every Execution Path

One possible correction is to assign an address to `pi` when `prev` is not `NULL`.

```
#include <stdlib.h>

int* assign_pointer(int* prev)
{
    int j = 42;
    int* pi;

    if (prev == NULL)
       {
        pi = (int*)malloc(sizeof(int));
        if (pi == NULL) return NULL;
       }
    /* Fix: Initialize pi in branches of if statement  */
    else
```

```
        pi = prev;


    *pi = j;

    return pi;
}
```

Non-initialized variable

Description

Non-initialized variable occurs when a variable is not initialized before its value is read.

Risk

Unless a variable is explicitly initialized, the variable value is unpredictable. You cannot rely on the variable having a specific value.

Fix

The fix depends on the root cause of the defect. For instance, you assigned a value to the variable but the assignment is unreachable or you assigned a value to the variable in one of two branches of a conditional statement. Fix the unreachable code or missing assignment.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below. It is a good practice to initialize a variable at declaration.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Non-initialized variable error

```
int get_sensor_value(void)
{
    extern int getsensor(void);
    int command;
    int val;
```

```
    command = getsensor();
    if (command == 2)
      {
        val = getsensor();
      }

    return val;
    /* Defect: val does not have a value if command is not 2 */
}
```

If `command` is not 2, the variable `val` is unassigned. In this case, the return value of function `get_sensor_value` is undetermined.

Correction — Initialize During Declaration

One possible correction is to initialize `val` during declaration so that the initialization is not bypassed on some execution paths.

```
int get_sensor_value(void)
{
    extern int getsensor(void);
    int command;
    /* Fix: Initialize val */
    int val=0;

    command = getsensor();
    if (command == 2)
      {
        val = getsensor();
      }

    return val;
 }
```

`val` is assigned an initial value of 0. When `command` is not equal to 2, the function `get_sensor_value` returns this value.

Check Information

Group: Rule 03. Expressions (EXP)

See Also

External Websites

EXP33-C

Introduced in R2019a

CERT C: Rule EXP34-C

Do not dereference null pointers

Description

Rule Definition

Do not dereference null pointers.

Examples

Null pointer

Description

Null pointer occurs when you use a pointer with a value of `NULL` as if it points to a valid memory location.

Risk

Dereferencing a null pointer is undefined behavior. In most implementations, the dereference can cause your program to crash.

Fix

Check a pointer for `NULL` before dereference.

If the issue occurs despite an earlier check for `NULL`, look for intermediate events between the check and the subsequent dereference. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

Example - Null pointer error

```
#include <stdlib.h>

int FindMax(int *arr, int Size)
{
 int* p=NULL;

 *p=arr[0];
 /* Defect: Null pointer dereference */

 for(int i=0;i<Size;i++)
  {
   if(arr[i] > (*p))
     *p=arr[i];
  }

 return *p;
}
```

The pointer `p` is initialized with value of `NULL`. However, when the value `arr[0]` is written to `*p`, `p` is assumed to point to a valid memory location.

Correction — Assign Address to Null Pointer Before Dereference

One possible correction is to initialize `p` with a valid memory address before dereference.

```
#include <stdlib.h>

int FindMax(int *arr, int Size)
{
 /* Fix: Assign address to null pointer */
 int* p=&arr[0];

 for(int i=0;i<Size;i++)
  {
   if(arr[i] > (*p))
     *p=arr[i];
  }

 return *p;
}
```

Check Information

Group: Rule 03. Expressions (EXP)

See Also

External Websites

EXP34-C

Introduced in R2019a

CERT C: Rule EXP35-C

Do not modify objects with temporary lifetime

Description

Rule Definition

Do not modify objects with temporary lifetime.

Examples

Accessing object with temporary lifetime

Description

Accessing object with temporary lifetime occurs when you attempt to read from or write to an object with temporary lifetime that is returned by a function call. In a structure or union returned by a function, and containing an array, the array members are temporary objects. The lifetime of temporary objects ends:

- When the full expression or full declarator containing the call ends, as defined in the C11 Standard.
- After the next sequence point, as defined in the C90 and C99 Standards. A sequence point is a point in the execution of a program where all previous evaluations are complete and no subsequent evaluation has started yet.

For C++ code, **Accessing object with temporary lifetime** raises a defect only when you write to an object with a temporary lifetime.

If the temporary lifetime object is returned by address, no defect is raised.

Risk

Modifying objects with temporary lifetime is undefined behavior and can cause abnormal program termination and portability issues.

Fix

Assign the object returned from the function call to a local variable. The content of the temporary lifetime object is copied to the variable. You can now modify it safely.

Example - Modifying Temporary Lifetime Object Returned by Function Call

```
#include <stdio.h>
#include <assert.h>
#include <stdlib.h>
#include <string.h>

#define SIZE6 6

struct S_Array
{
    int t;
    int a[SIZE6];
};

struct S_Array func_temp(void);

/* func_temp() returns a struct value containing
* an array with a temporary lifetime.
*/
int func(void) {

/*Writing to temporary lifetime object is
 undefined behavior
 */
    return ++(func_temp().a[0]);
}

void main(void) {
    (void)func();
}
```

In this example, `func_temp()` returns by value a structure with an array member `a`. This member has temporary lifetime. Incrementing it is undefined behavior.

Correction — Assign Returned Value to Local Variable Before Writing

One possible correction is to assign the return of the call to `func_temp()` to a local variable. The content of the temporary object `a` is copied to the variable, which you can safely increment.

```
 #include <stdio.h>
#include <assert.h>
#include <stdlib.h>
#include <string.h>

#define SIZE6 6

struct S_Array
{
    int t;
    int a[SIZE6];
};

struct S_Array func_temp(void);

int func(void) {

/* Assign object returned by function call to
 *local variable
 */
    struct S_Array s = func_temp();

/* Local variable can safely be
 *incremented
 */
    ++(s.a[0]);
    return s.a[0];
}

void main(void) {
    (void)func();
}
```

Check Information

Group: Rule 03. Expressions (EXP)

See Also

External Websites

EXP35-C

Introduced in R2019a

CERT C: Rule EXP36-C

Do not cast pointers into more strictly aligned pointer types

Description

Rule Definition

Do not cast pointers into more strictly aligned pointer types.

Examples

Wrong allocated object size for cast

Description

Wrong allocated object size for cast occurs during pointer conversion when the pointer's address is misaligned. If a pointer is converted to a different pointer type, the size of the allocated memory must be a multiple of the size of the destination pointer.

Risk

Dereferencing a misaligned pointer has undefined behavior and can cause your program to crash.

Fix

Suppose you convert a pointer `ptr1` to `ptr2`. If `ptr1` points to a buffer of `N` bytes and `ptr2` is a *`type`* `*` pointer where `sizeof(`*`type`*`)` is `n` bytes, make sure that `N` is an integer multiple of `n`.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See "Address Polyspace Results Through Bug Fixes or Comments".

Example - Dynamic Allocation of Pointers

```
#include <stdlib.h>

void dyn_non_align(void){
    void *ptr = malloc(13);
    long *dest;

    dest = (long*)ptr; //defect
}
```

In this example, the software raises a defect on the conversion of `ptr` to a `long*`. The dynamically allocated memory of `ptr`, 13 bytes, is not a multiple of the size of `dest`, 4 bytes. This misalignment causes the **Wrong allocated object size for cast** defect.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the allocated memory to 12 instead of 13.

```
#include <stdlib.h>

void dyn_non_align(void){
    void *ptr = malloc(12);
    long *dest;

    dest = (long*)ptr;
}
```

Example - Static Allocation of Pointers

```
void static_non_align(void){
    char arr[13], *ptr;
    int *dest;

    ptr = &arr[0];
    dest = (int*)ptr; //defect
}
```

In this example, the software raises a defect on the conversion of `ptr` to an `int*` in line 6. `ptr` has a memory size of 13 bytes because the array `arr` has a size of 13 bytes. The size of `dest` is 4 bytes, which is not a multiple of 13. This misalignment causes the **Wrong allocated object size for cast** defect.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the size of the array `arr` to a multiple of 4.

```
void static_non_align(void){
    char arr[12], *ptr;
    int *dest;

    ptr = &arr[0];
    dest = (int*)ptr;
}
```

Example - Allocation with a Function

```
#include <stdlib.h>

void *my_alloc(int size) {
    void *ptr_func = malloc(size);
    if(ptr_func == NULL) exit(-1);
    return ptr_func;
}

void fun_non_align(void){
    int *dest1;
    char *dest2;

    dest1 = (int*)my_alloc(13);  //defect
    dest2 = (char*)my_alloc(13); //not a defect
}
```

In this example, the software raises a defect on the conversion of the pointer returned by `my_alloc(13)` to an `int*` in line 11. `my_alloc(13)` returns a pointer with a dynamically allocated size of 13 bytes. The size of `dest1` is 4 bytes, which is not a divisor of 13. This misalignment causes the **Wrong allocated object size for cast** defect. In line 12, the same function call, `my_alloc(13)`, does not call a defect for the conversion to `dest2` because the size of `char*`, 1 byte, a divisor of 13.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the argument for `my_alloc` to a multiple of 4.

```
#include <stdlib.h>

void *my_alloc(int size) {
    void *ptr_func = malloc(size);
    if(ptr_func == NULL) exit(-1);
    return ptr_func;
}

void fun_non_align(void){
    int *dest1;
    char *dest2;

    dest1 = (int*)my_alloc(12);
    dest2 = (char*)my_alloc(13);
}
```

Check Information

Group: Rule 03. Expressions (EXP)

See Also

External Websites

EXP36-C

Introduced in R2019a

CERT C: Rule EXP37-C

Call functions with the correct number and type of arguments

Description

Rule Definition

Call functions with the correct number and type of arguments.

Examples

Implicit function declaration

Description

The issue occurs when you call a function before you declare or define it.

Risk

An implicit declaration occurs when you call a function before declaring or defining it. When you declare a function explicitly before calling it, the compiler can match the argument and return types with the parameter types in the declaration. If an implicit declaration occurs, the compiler makes assumptions about the argument and return types. For instance, it assumes a return type of `int`. The assumptions might not agree with what you expect and cause undesired type conversions.

Example - Function Not Declared Before Call

```
#include <math.h>

extern double power3 (double val, int exponent);
int getChoice(void);

double func() {
    double res;
```

```
    int ch = getChoice();
    if(ch == 0) {
        res = power(2.0, 10);    /* Non-compliant */
    }
    else if( ch==1) {
        res = power2(2.0, 10);   /* Non-compliant */
    }
    else {
        res = power3(2.0, 10);   /* Compliant */
        return res;
    }
}

double power2 (double val, int exponent) {
    return (pow(val, exponent));
}
```

In this example, the rule is violated when a function that is not declared is called in the code. Even if a function definition exists later in the code, the rule violation occurs.

The rule is not violated when the function is declared before it is called in the code. If the function definition exists in another file and is available only during the link phase, you can declare the function in one of the following ways:

- Declare the function with the `extern` keyword in the current file.
- Declare the function in a header file and include the header file in the current file.

Bad file access mode or status

Description

Bad file access mode or status occurs when you use functions in the `fopen` or `open` group with invalid or incompatible file access modes, file creation flags, or file status flags as arguments. For instance, for the `open` function, examples of valid:

- Access modes include `O_RDONLY`, `O_WRONLY`, and `O_RDWR`
- File creation flags include `O_CREAT`, `O_EXCL`, `O_NOCTTY`, and `O_TRUNC`.
- File status flags include `O_APPEND`, `O_ASYNC`, `O_CLOEXEC`, `O_DIRECT`, `O_DIRECTORY`, `O_LARGEFILE`, `O_NOATIME`, `O_NOFOLLOW`, `O_NONBLOCK`, `O_NDELAY`, `O_SHLOCK`, `O_EXLOCK`, `O_FSYNC`, `O_SYNC` and so on.

The defect can occur in the following situations.

Situation	Risk	Fix
You pass an empty or invalid access mode to the `fopen` function. According to the ANSI C standard, the valid access modes for `fopen` are: • `r`,`r+` • `w`,`w+` • `a`,`a+` • `rb`, `wb`, `ab` • `r+b`, `w+b`, `a+b` • `rb+`, `wb+`, `ab+`	`fopen` has undefined behavior for invalid access modes. Some implementations allow extension of the access mode such as: • GNU: `rb +cmxe,ccs=utf` • Visual C++: `a+t`, where `t` specifies a text mode. However, your access mode string must begin with one of the valid sequences.	Pass a valid access mode to `fopen`.
You pass the status flag `O_APPEND` to the `open` function without combining it with either `O_WRONLY` or `O_RDWR`.	`O_APPEND` indicates that you intend to add new content at the end of a file. However, without `O_WRONLY` or `O_RDWR`, you cannot write to the file. The `open` function does not return -1 for this logical error.	Pass either `O_APPEND|O_WRONLY` or `O_APPEND|O_RDWR` as access mode.
You pass the status flags `O_APPEND` and `O_TRUNC` together to the `open` function.	`O_APPEND` indicates that you intend to add new content at the end of a file. However, `O_TRUNC` indicates that you intend to truncate the file to zero. Therefore, the two modes cannot operate together. The `open` function does not return -1 for this logical error.	Depending on what you intend to do, pass one of the two modes.

Situation	Risk	Fix
You pass the status flag `O_ASYNC` to the `open` function.	On certain implementations, the mode `O_ASYNC` does not enable signal-driven I/O operations.	Use the `fcntl(pathname, F_SETFL, O_ASYNC);` instead.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Invalid Access Mode with `fopen`

```
#include <stdio.h>

void func(void) {
    FILE *file = fopen("data.txt", "rw");
    if(file!=NULL) {
        fputs("new data",file);
        fclose(file);
    }
}
```

In this example, the access mode `rw` is invalid. Because `r` indicates that you open the file for reading and `w` indicates that you create a new file for writing, the two access modes are incompatible.

Correction — Use Either `r` or `w` as Access Mode

One possible correction is to use the access mode corresponding to what you intend to do.

```
#include <stdio.h>

void func(void) {
    FILE *file = fopen("data.txt", "w");
    if(file!=NULL) {
```

```
        fputs("new data",file);
        fclose(file);
    }
}
```

Unreliable cast of function pointer

Description

Unreliable cast of function pointer occurs when a function pointer is cast to another function pointer that has different argument or return type.

This defect applies only if the code language for the project is C.

Risk

If you cast a function pointer to another function pointer with different argument or return type and then use the latter function pointer to call a function, the behavior is undefined.

Fix

Avoid a cast between two function pointers with mismatch in argument or return types.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Unreliable cast of function pointer error

```
#include <stdio.h>
#include <math.h>
#include <stdio.h>
#define PI 3.142

double Calculate_Sum(int (*fptr)(double))
{
    double  sum = 0.0;
    double  y;

    for (int i = 0;  i <= 100;  i++)
    {
```

```
        y = (*fptr)(i*PI/100);
        sum += y;
    }
    return sum / 100;
}

int main(void)
{
    double  (*fp)(double);
    double  sum;

    fp = sin;
    sum = Calculate_Sum(fp);
    /* Defect: fp implicitly cast to int(*) (double) */

    printf("sum(sin): %f\n", sum);
    return 0;
}
```

The function pointer `fp` is declared as `double (*)(double)`. However in passing it to function `Calculate_Sum`, `fp` is implicitly cast to `int (*)(double)`.

Correction — Avoid Function Pointer Cast

One possible correction is to check that the function pointer in the definition of `Calculate_Sum` has the same argument and return type as `fp`. This step makes sure that `fp` is not implicitly cast to a different argument or return type.

```
#include <stdio.h>
#include <math.h>
#include <stdio.h>
# define PI 3.142

/*Fix: fptr has same argument and return type everywhere*/
double Calculate_Sum(double (*fptr)(double))
{
    double  sum = 0.0;
    double y;

    for (int i = 0;  i <= 100;  i++)
    {
        y = (*fptr)(i*PI/100);
        sum += y;
    }
```

```
    return sum / 100;
}

int main(void)
{
    double  (*fp)(double);
    double  sum;


    fp = sin;
    sum = Calculate_Sum(fp);
    printf("sum(sin): %f\n", sum);

    return 0;
}
```

Standard function call with incorrect arguments

Description

Standard function call with incorrect arguments occurs when the arguments to certain standard functions do not meet the requirements for their use in the functions.

For instance, the arguments to these functions can be invalid in the following ways.

Function Type	Situation	Risk	Fix
String manipulation functions such as `strlen` and `strcpy`	The pointer arguments do not point to a `NULL`-terminated string.	The behavior of the function is undefined.	Pass a `NULL`-terminated string to string manipulation functions.
File handling functions in `stdio.h` such as `fputc` and `fread`	The `FILE*` pointer argument can have the value `NULL`.	The behavior of the function is undefined.	Test the `FILE*` pointer for `NULL` before using it as function argument.

Function Type	Situation	Risk	Fix
File handling functions in `unistd.h` such as `lseek` and `read`	The file descriptor argument can be -1.	The behavior of the function is undefined. Most implementations of the `open` function return a file descriptor value of -1. In addition, they set `errno` to indicate that an error has occurred when opening a file.	Test the return value of the `open` function for -1 before using it as argument for `read` or `lseek`. If the return value is -1, check the value of `errno` to see which error has occurred.
	The file descriptor argument represents a closed file descriptor.	The behavior of the function is undefined.	Close the file descriptor only after you have completely finished using it. Alternatively, reopen the file descriptor before using it as function argument.
Directory name generation functions such as `mkdtemp` and `mkstemps`	The last six characters of the string template are not XXXXXX.	The function replaces the last six characters with a string that makes the file name unique. If the last six characters are not XXXXXX, the function cannot generate a unique enough directory name.	Test if the last six characters of a string are XXXXXX before using the string as function argument.

Function Type	Situation	Risk	Fix
Functions related to environment variables such as `getenv` and `setenv`	The string argument is `""`.	The behavior is implementation-defined.	Test the string argument for `""` before using it as `getenv` or `setenv` argument.
	The string argument terminates with an equal sign, `=`. For instance, `"C="` instead of `"C"`.	The behavior is implementation-defined.	Do not terminate the string argument with `=`.
String handling functions such as `strtok` and `strstr`	• `strtok`: The delimiter argument is `""`. • `strstr`: The search string argument is `""`.	Some implementations do not handle these edge cases.	Test the string for `""` before using it as function argument.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - NULL Pointer Passed as `strnlen` Argument

```
#include <string.h>
#include <stdlib.h>

enum {
    SIZE10 = 10,
    SIZE20 = 20
};
```

```
int func() {
    char* s = NULL;
    return strnlen(s, SIZE20);
}
```

In this example, a `NULL` pointer is passed as `strnlen` argument instead of a `NULL`-terminated string.

Before running analysis on the code, specify a GNU compiler. See `Compiler (-compiler)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Correction — Pass NULL-terminated String

Pass a `NULL`-terminated string as the first argument of `strnlen`.

```
#include <string.h>
#include <stdlib.h>

enum {
    SIZE10 = 10,
    SIZE20 = 20
};

int func() {
    char* s = "";
    return strnlen(s, SIZE20);
}
```

Check Information

Group: Rule 03. Expressions (EXP)

See Also

External Websites

EXP37-C

Introduced in R2019a

CERT C: Rule EXP39-C

Do not access a variable through a pointer of an incompatible type

Description

Rule Definition

Do not access a variable through a pointer of an incompatible type.

Examples

Cast to pointer pointing to object of different type

Description

The issue occurs when you perform a cast between a pointer to an object type and a pointer to a different object type.

Risk

If a pointer to an object is cast into a pointer to a different object, the resulting pointer can be incorrectly aligned. The incorrect alignment causes undefined behavior.

Even if the conversion produces a pointer that is correctly aligned, the behavior can be undefined if the pointer is used to access an object.

Exception: You can convert a pointer to object type into a pointer to one of the following types:

- `char`
- `signed char`
- `unsigned char`

Example - Noncompliant: Cast to Pointer Pointing to Object of Wider Type

```
signed   char *p1;
unsigned int *p2;

void foo(void){
  p2 = ( unsigned int * ) p1;     /* Non-compliant */
}
```

In this example, `p1` can point to a `signed char` object. However, `p1` is cast to a pointer that points to an object of wider type, `unsigned int`.

Example - Noncompliant: Cast to Pointer Pointing to Object of Narrower Type

```
extern unsigned int read_value ( void );
extern void display ( unsigned int n );

void foo ( void ){
  unsigned int u = read_value ( );
  unsigned short *hi_p = ( unsigned short * ) &u;    /* Non-compliant  */
  *hi_p = 0;
  display ( u );
}
```

In this example, `u` is an `unsigned int` variable. `&u` is cast to a pointer that points to an object of narrower type, `unsigned short`.

On a big-endian machine, the statement `*hi_p = 0` attempts to clear the high bits of the memory location that `&u` points to. But, from the result of `display(u)`, you might find that the high bits have not been cleared.

Example - Compliant: Cast Adding a Type Qualifier

```
const short *p;
const volatile short *q;
void foo (void){
  q = ( const volatile short * ) p;  /* Compliant */
}
```

In this example, both `p` and `q` can point to `short` objects. The cast between them adds a `volatile` qualifier only and is therefore compliant.

Check Information

Group: Rule 03. Expressions (EXP)

See Also

External Websites

EXP39-C

Introduced in R2019a

CERT C: Rule EXP40-C

Do not modify constant objects

Description

Rule Definition

Do not modify constant objects.

Examples

Writing to const qualified object

Description

Writing to `const` qualified object occurs when you do one of the following:

- Use a `const`-qualified object as the destination of an assignment.
- Pass a `const`-qualified object to a function that modifies the argument.

For instance, the defect can occur in the following situations:

- You pass a `const`-qualified object as first argument of one of the following functions:
  - `mkstemp`
  - `mkostemp`
  - `mkostemps`
  - `mkdtemp`
- You pass a `const`-qualified object as the destination argument of one of the following functions:
  - `strcpy`
  - `strncpy`

  - `strcat`
  - `memset`
- You perform a write operation on a `const`-qualified object.

Risk

The risk depends upon the modifications made to the `const`-qualified object.

Situation	Risk
Passing to `mkstemp`, `mkostemp`, `mkostemps`, `mkdtemp`, and so on.	These functions replace the last six characters of their first argument with a string. Therefore, they expect a modifiable `char` array as their first argument.
Passing to `strcpy`, `strncpy`, `strcat`, `memset` and so on.	These functions modify their destination argument. Therefore, they expect a modifiable `char` array as their destination argument.
Writing to the object	The `const` qualifier implies an agreement that the value of the object will not be modified. By writing to a `const`-qualified object, you break the agreement. The result of the operation is undefined.

Fix

The fix depends on the modification made to the `const`-qualified object.

Situation	Fix
Passing to `mkstemp`, `mkostemp`, `mkostemps`, `mkdtemp`, and so on.	Pass a non-`const` object as first argument of the function.
Passing to `strcpy`, `strncpy`, `strcat`, `memset` and so on.	Pass a non-`const` object as destination argument of the function.
Writing to the object	Perform the write operation on a non-`const` object.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Writing to `const`-Qualified Object

```
#include <string.h>

const char* buffer = "abcdeXXXXXXX";

void func(char* string) {
    char *ptr = (char*)strchr(buffer,'X');
    if(ptr)
        strcpy(ptr,string);
}
```

In this example, because `buffer` is `const`-qualified, `strchr(buffer,'X')` returns a `const`-qualified `char*` pointer. When this `char*` pointer is used as the destination argument of `strcpy`, a **Writing to const qualified object** error appears.

Correction — Copy `const`-Qualified Object to Non-`const` Object

One possible correction is to assign the constant string to a non-`const` object and use the non-`const` object as destination argument of `strchr`.

```
#include <string.h>

char buffer[] = "abcdeXXXXXXX";

void func(char* string) {
    char *ptr = (char*)strchr(buffer,'X');
    if(ptr)
        strcpy(ptr,string);
}
```

Check Information

Group: Rule 03. Expressions (EXP)

See Also

External Websites

EXP40-C

Introduced in R2019a

CERT C: Rule EXP42-C

Do not compare padding data

Description

Rule Definition

Do not compare padding data.

Examples

Memory comparison of padding data

Description

Memory comparison of padding data occurs when you use the `memcmp` function to compare two structures as a whole. In the process, you compare meaningless data stored in the structure padding.

For instance:

```
struct structType {
    char member1;
    int member2;
    .
    .
};

structType var1;
structType var2;
.
.
if(memcmp(&var1,&var2,sizeof(var1)))
{...}
```

Risk

If members of a structure have different data types, your compiler introduces additional padding for data alignment in memory. For an example of padding, see `Higher Estimate of Local Variable Size`.

The content of these extra padding bytes is meaningless. The C Standard allows the content of these bytes to be indeterminate, giving different compilers latitude to implement their own padding. If you perform a byte-by-byte comparison of structures with `memcmp`, you compare even the meaningless data stored in the padding. You might reach the false conclusion that two data structures are not equal, even if their corresponding members have the same value.

Fix

Instead of comparing two structures in one attempt, compare the structures member by member.

For efficient code, write a function that does the comparison member by member. Use this function for comparing two structures.

You can use `memcmp` for byte-by-byte comparison of structures only if you know that the structures do not contain padding. Typically, to prevent padding, you use specific attributes or pragmas such as `#pragma pack`. However, these attributes or pragmas are not supported by all compilers and make your code implementation-dependent. If your structures contain bit-fields, using these attributes or pragmas cannot prevent padding.

Example - Structures Compared with `memcmp`

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define fatal_error() abort()

typedef struct s_padding
{
    char c;
    int i;
    unsigned int bf1:1;
    unsigned int bf2:2;
    unsigned char buffer[20];
} S_Padding ;
```

```
/* Function that guarantees safe access to the input memory */
extern int trusted_memory_zone(void *ptr, size_t sz);

int func(const S_Padding *left, const S_Padding *right)
{

    if (!trusted_memory_zone((void *)left, sizeof(S_Padding)) ||
        !trusted_memory_zone((void *)right, sizeof(S_Padding))) {
        fatal_error();
    }

    if (0 == memcmp(left, right, sizeof(S_Padding)))
    {
        return 1;
    }
    else
        return 0;
}
```

In this example, `memcmp` compares byte-by-byte the two structures that `left` and `right` point to. Even if the values stored in the structure members are the same, the comparison can show an inequality if the meaningless values in the padding bytes are not the same.

Correction — Compare Structures Member by Member

One possible correction is to compare individual structure members.

Note You can compare entire arrays by using `memcmp`. All members of an array have the same data type. Padding bytes are not required to store arrays.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define fatal_error() abort()

typedef struct s_padding
{
    char c;
    int i;
    unsigned int bf1:1;
```

```
    unsigned int bf2:2;
    unsigned char buffer[20];
} S_Padding ;

/* Function that guarantees safe access to the input memory */
extern int trusted_memory_zone(void *ptr, size_t sz);

int func(const S_Padding *left, const S_Padding *right)
{
    if (!trusted_memory_zone((void *)left, sizeof(S_Padding)) ||
        !trusted_memory_zone((void *)right, sizeof(S_Padding))) {
        fatal_error();
    }

    return ((left->c == right->c) &&
            (left->i == right->i) &&
            (left->bf1 == right->bf1) &&
            (left->bf2 == right->bf2) &&
            (memcmp(left->buffer, right->buffer, 20) == 0));
}
```

Check Information

Group: Rule 03. Expressions (EXP)

See Also

External Websites

EXP42-C

Introduced in R2019a

CERT C: Rule EXP43-C

Avoid undefined behavior when using restrict-qualified pointers

Description

Rule Definition

Avoid undefined behavior when using restrict-qualified pointers.

Examples

Copy of overlapping memory

Description

Copy of overlapping memory occurs when there is a memory overlap between the source and destination argument of a copy function such as `memcpy` or `strcpy`. For instance, the source and destination arguments of `strcpy` are pointers to different elements in the same string.

Risk

If there is memory overlap between the source and destination arguments of copy functions, according to C standards, the behavior is undefined.

Fix

Determine if the memory overlap is what you want. If so, find an alternative function. For instance:

- If you are using `memcpy` to copy values from one memory location to another, use `memmove` instead of `memcpy`.
- If you are using `strcpy` to copy one string to another, use `memmove` instead of `strcpy`, as follows:

```
s = strlen(source);
memmove(destination, source, s + 1);
```

`strlen` determines the string length without the null terminator. Therefore, you must move `s+1` bytes instead of `s` bytes.

Example - Overlapping Copy

```
#include <string.h>

char str[] = {"ABCDEFGH"};

void my_copy() {
    strcpy(&str[0],(const char*)&str[2]);
}
```

In this example, because the source and destination argument are pointers to the same string `str`, there is memory overlap between their allowed buffers.

Check Information

Group: Rule 03. Expressions (EXP)

See Also

External Websites

EXP43-C

Introduced in R2019a

CERT C: Rule EXP44-C

Do not rely on side effects in operands to sizeof, _Alignof, or _Generic

Description

Rule Definition

Do not rely on side effects in operands to sizeof, _Alignof, or _Generic.

Examples

Side effect of expression ignored

Description

Side effect of expression ignored occurs when the `sizeof`, `_Alignof`, or `_Generic` operator operates on an expression with a side effect. When evaluated, an expression with side effect modifies at least one of the variables in the expression.

For instance, the defect checker does not flag `sizeof(n+1)` because `n+1` does not modify `n`. The checker flags `sizeof(n++)` because `n++` is intended to modify `n`.

The check also applies to the C++ operator `alignof` and its C extensions, `__alignof__` and `__typeof__`.

Risk

The expression in a `_Alignof` or `_Generic` operator is not evaluated. The expression in a `sizeof` operator is evaluated only if it is required for calculating the size of a variable-length array, for instance, `sizeof(a[n++])`.

When an expression with a side effect is not evaluated, the variable modification from the side effect does not happen. If you rely on the modification, you can see unexpected results.

Fix

Evaluate the expression with a side effect in a separate statement, and then use the result in a `sizeof`, `_Alignof`, or `_Generic` operator.

For instance, instead of:

```
a = sizeof(n++);
```

perform the operation in two steps:

```
n++;
a = sizeof(n);
```

The checker considers a function call as an expression with a side effect. Even if the function does not have side effects now, it might have side effects on later additions. The code is more maintainable if you call the function outside the `sizeof` operator.

Example - Increment Operator in `sizeof`

```
#include <stdio.h>

void func(void) {
    unsigned int a = 1U;
    unsigned int b = (unsigned int)sizeof(++a);
    printf ("%u, %u\n", a, b);
}
```

In this example, `sizeof` operates on `++a`, which is intended to modify `a`. Because the expression is not evaluated, the modification does not happen. The `printf` statement shows that `a` still has the value `1`.

Correction — Perform Increment Outside `sizeof`

One possible correction is to perform the increment first, and then provide the result to the `sizeof` operator.

```
#include <stdio.h>

void func(void) {
    unsigned int a = 1U;
    ++a;
    unsigned int b = (unsigned int)sizeof (a);
    printf ("%u, %u\n", a, b);
}
```

Check Information

Group: Rule 03. Expressions (EXP)

See Also

External Websites

EXP44-C

Introduced in R2019a

CERT C: Rule EXP45-C

Do not perform assignments in selection statements

Description

Rule Definition

Do not perform assignments in selection statements.

Examples

Invalid use of = (assignment) operator

Description

Invalid use of = operator occurs when an assignment is made inside the predicate of a conditional, such as `if` or `while`.

In C and C++, a single equal sign is an assignment not a comparison. Using a single equal sign in a conditional statement can indicate a typo or a mistake.

Risk

- Conditional statement tests the wrong values— The single equal sign operation assigns the value of the right operand to the left operand. Then, because this assignment is inside the predicate of a conditional, the program checks whether the new value of the left operand is nonzero or not NULL.
- Maintenance and readability issues — Even if the assignment is intended, someone reading or updating the code can misinterpret the assignment as an equality comparison instead of an assignment.

Fix

- If the assignment is a bug, to check for equality, add a second equal sign (==).

- If the assignment inside the conditional statement was intentional, to improve readability, separate the assignment and the test. Move the assignment outside the control statement. In the control statement, simply test the result of the assignment.

  If you do not want to fix the issue, add comments to your result or code to avoid another review. See "Address Polyspace Results Through Bug Fixes or Comments".

Example - Single Equal Sign Inside an `if` Condition

```
#include <stdio.h>

void bad_equals_ex(int alpha, int beta)
{
    if(alpha = beta)
    {
        printf("Equal\n");
    }
}
```

The equal sign is flagged as a defect because the assignment operator is used within the predicate of the if-statement. The predicate assigns the value `beta` to `alpha`, then implicitly tests whether `alpha` is true or false.

Correction — Change Expression to Comparison

One possible correction is adding an additional equal sign. This correction changes the assignment to a comparison. The if condition compares whether `alpha` and `beta` are equal.

```
#include <stdio.h>

void equality_test(int alpha, int beta)
{
    if(alpha == beta)
    {
        printf("Equal\n");
    }
}
```

Correction — Assignment and Comparison Inside the `if` Condition

If an assignment must be made inside the predicate, a possible correction is adding an explicit comparison. This correction assigns the value of `beta` to `alpha`, then explicitly checks whether `alpha` is nonzero. The code is clearer.

```
#include <stdio.h>

int assignment_not_zero(int alpha, int beta)
{
    if((alpha = beta) != 0)
    {
        return alpha;
    }
    else
    {
        return 0;
    }
}
```

Correction — Move Assignment Outside the `if` Statement

If the assignment can be made outside the control statement, one possible correction is to separate the assignment and comparison. This correction assigns the value of `beta` to `alpha` before the if. Inside the if-condition, only `alpha` is given to test if `alpha` is nonzero or not NULL.

```
#include <stdio.h>

void assign_and_print(int alpha, int beta)
{
    alpha = beta;
    if(alpha)
    {
        printf("%d", alpha);
    }
}
```

Check Information

Group: Rule 03. Expressions (EXP)

See Also

External Websites

EXP45-C

Introduced in R2019a

CERT C: Rule EXP46-C

Do not use a bitwise operator with a Boolean-like operand

Description

Rule Definition

Do not use a bitwise operator with a Boolean-like operand.

Examples

Possible invalid operation on boolean operand

Description

Possible invalid operation on boolean operand occurs when you use a Boolean operand in an arithmetic, relational, or bitwise operation and:

- The Boolean operand has a trap representation. The size of a Boolean type in memory is at least one addressable unit (size of `char`). A Boolean type requires only one bit to represent the value `true (1)` or `false (0)`. The representation of a Boolean operand in memory contains padding bits. The memory representation can result in values that are not `true` or `false`, a trap representation.
- The result of the operation can exceed the precision of the Boolean operand.

For example, in this code snippet:

```
bool_v >> 2
```

- If the value of `bool_v` is `true (1)` or `false (0)`, the bitwise shift exceeds the one-bit precision of `bool_v` and always results in `0`.
- If `bool_v` has a trap representation, the result of the operation is an arbitrary value.

Possible invalid operation on boolean operand raises no defect when:

- The operation does not result in a precision overflow. For instance, bitwise & or | operations with `0x01` or `0x00`.
- The Boolean operand cannot have a trap representation. For instance, a constant expression that results in `0` or `1`, or a comparison evaluated to `true` or `false`.

Risk

Arithmetic, relational, or bitwise operations on a Boolean operand can exceed the operand precision and cause unexpected results when used as a Boolean value. Operations on Boolean operands with trap representations can return arbitrary values.

Fix

Avoid performing operations on Boolean operands other than these operations:

- Assignment operation (=).
- Equality operations (== or !=).
- Logical operations (&&, ||, or !).

Example - Possible Trap Representation of Boolean Operand

```
#include <stdio.h>
#include <stdbool.h>

#define BOOL _Bool

int arr[2] = {1, 2};

int func(BOOL b)
{
    return arr[b];
}

int main(void)
{
    BOOL b;
    char* ptr = (char*)&b;
    *ptr = 64;
    return func(b);
}
```

In this example, Boolean operand `b` is used as an array index in `func` for an array with two elements. Depending on the compiler and optimization flags you use, the value `b`

might not be `0` or `1`. For instance, in Linux Debian 8, if you use `gcc` version 4.9 with optimization flag `-O0`, the value of `b` is 64, which causes a buffer overflow.

Correction — Use Only Last Significant Bit Value of Boolean Operand

One possible correction is to use a variable `b0` of type `unsigned int` to get only the value of the last significant bit of the Boolean operand. The value of this bit is in the range `[0..1]`, even if the Boolean operand has a trap representation.

```
#include <stdio.h>
#include <stdbool.h>

#define BOOL _Bool

int arr[2] = {1, 2};

int func(BOOL b)
{
    unsigned int b0 = (unsigned int)b;
    b0 &= 0x1;
    return arr[b0];
}

int main(void)
{
    BOOL b;
    char* ptr = (char*)&b;
    *ptr = 64;
    return func(b);
}
```

Check Information

Group: Rule 03. Expressions (EXP)

See Also

External Websites

EXP46-C

Introduced in R2019a

CERT C: Rule EXP47-C

Do not call va_arg with an argument of the incorrect type

Description

Rule Definition

Do not call va_arg with an argument of the incorrect type.

Examples

Incorrect data type passed to va_arg

Description

Incorrect data type passed to va_arg when the data type in a `va_arg` call does not match the data type of the variadic function argument that `va_arg` reads.

For instance, you pass an `unsigned char` argument to a variadic function `func`. Because of default argument promotion, the argument is promoted to `int`. When you use a `va_arg` call that reads an `unsigned char` argument, a type mismatch occurs.

```
void func (int n, ...) {
   ...
   va_list args;
   va_arg(args, unsigned char);
   ...
}

void main(void) {
   unsigned char c;
   func(1,c);
}
```

Risk

In a variadic function (function with variable number of arguments), you use `va_arg` to read each argument from the variable argument list (`va_list`). The `va_arg` use does not guarantee that there actually exists an argument to read or that the argument data type matches the data type in the `va_arg` call. You have to make sure that both conditions are true.

Reading an incorrect type with a `va_arg` call can result in undefined behavior. Because function arguments reside on the stack, you might access an unwanted area of the stack.

Fix

Make sure that the data type of the argument passed to the variadic function matches the data type in the `va_arg` call.

Arguments of a variadic function undergo default argument promotions. The argument data types of a variadic function cannot be determined from a prototype. The arguments of such functions undergo default argument promotions (see Sec. 6.5.2.2 and 7.15.1.1 in the C99 Standard). Integer arguments undergo integer promotion and arguments of type `float` are promoted to `double`. For integer arguments, if a data type can be represented by an `int`, for instance, `char` or `short`, it is promoted to an `int`. Otherwise, it is promoted to an `unsigned int`. All other arguments do not undergo promotion.

To avoid undefined and implementation-defined behavior, minimize the use of variadic functions. Use the checkers for `MISRA C:2012 Rule 17.1` or `MISRA C++:2008 Rule 8-4-1` to detect use of variadic functions.

Example - `char` Used as Function Argument Type and `va_arg` argument

```
#include <stdarg.h>
#include <stdio.h>

unsigned char func(size_t count, ...) {
    va_list ap;
    unsigned char result = 0;
    va_start(ap, count);
    if (count > 0) {
        result = va_arg(ap, unsigned char);
    }
    va_end(ap);
    return result;
}
```

```
void func_caller(void) {
    unsigned char c = 0x12;
    (void)func(1, c);
}
```

In this example, `func` takes an `unsigned char` argument, which undergoes default argument promotion to `int`. The data type in the `va_arg` call is still `unsigned char`, which does not match the `int` argument type.

Correction — Use `int` as `va_arg` Argument

One possible correction is to read an `int` argument with `va_arg`.

```
#include <stdarg.h>
#include <stdio.h>

unsigned char func(size_t count, ...) {
    va_list ap;
    unsigned char result = 0;
    va_start(ap, count);
    if (count > 0) {
        result = va_arg(ap, int);
    }
    va_end(ap);
    return result;
}

void func_caller(void) {
    unsigned char c = 0x12;
    (void)func(1, c);
}
```

Too many va_arg calls for current argument list

Description

Too many va_arg calls for current argument list occurs when the number of calls to `va_arg` exceeds the number of arguments passed to the corresponding variadic function. The analysis raises a defect only when the variadic function is called.

Too many va_arg calls for current argument list does not raise a defect when:

- The number of calls to `va_arg` inside the variadic function is indeterminate. For example, if the calls are from an external source.
- The `va_list` used in `va_arg` is invalid.

Risk

When you call `va_arg` and there is no next argument available in `va_list`, the behavior is undefined. The call to `va_arg` might corrupt data or return an unexpected result.

Fix

Ensure that you pass the correct number of arguments to the variadic function.

Example - No Argument Available When Calling `va_arg`

```
#include <stdarg.h>
#include <stddef.h>
#include <math.h>

/* variadic function defined with
* one named argument 'count'
*/
int variadic_func(int count, ...) {
    int result = -1;
    va_list ap;
    va_start(ap, count);
    if (count > 0) {
        result = va_arg(ap, int);
        count --;
        if (count > 0) {
/* No further argument available
* in va_list when calling va_arg
*/

            result += va_arg(ap, int);
        }
    }
    va_end(ap);
    return result;
}

void func(void) {

    (void)variadic_func(2, 100);
```

```
}
```

In this example, the named argument and only one variadic argument are passed to `variadic_func()` when it is called inside `func()`. On the second call to `va_arg`, no further variadic argument is available in `ap` and the behavior is undefined.

Correction — Pass Correct Number of Arguments to Variadic Function

One possible correction is to ensure that you pass the correct number of arguments to the variadic function.

```
#include <stdarg.h>
#include <stddef.h>
#include <math.h>

/* variadic function defined with
* one named argument 'count'
*/

int variadic_func(int count, ...) {
    int result = -1;
    va_list ap;
    va_start(ap, count);
    if (count > 0) {
        result = va_arg(ap, int);
        count --;
        if (count > 0) {

/* The correct number of arguments is
* passed to va_list when variadic_func()
* is called inside func()
*/
            result += va_arg(ap, int);
        }
    }
    va_end(ap);
    return result;
}

void func(void) {

    (void)variadic_func(2, 100, 200);

}
```

Check Information

Group: Rule 03. Expressions (EXP)

See Also

External Websites

EXP47-C

Introduced in R2019a

Rule 04. Integers (INT)

CERT C: Rule INT30-C

Ensure that unsigned integer operations do not wrap

Description

Rule Definition

Ensure that unsigned integer operations do not wrap.

Examples

Unsigned integer overflow

Description

Unsigned integer overflow occurs when an operation on unsigned integer variables can result in values that cannot be represented by the result data type. The data type of a variable determines the number of bytes allocated for the variable storage and constrains the range of allowed values.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

The C11 standard states that unsigned integer overflows result in wrap-around behavior. However, a wrap around behavior might not always be desirable. For instance, if the result of a computation is used as an array size and the computation overflows, the array size is much smaller than expected.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If

the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

You can fix the defect by:

- Using a bigger data type for the result of the operation so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling. In the error handling code, you can override the default wrap-around behavior for overflows and implement saturation behavior, for instance.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Add One to Maximum Unsigned Integer

```
#include <limits.h>

unsigned int plusplus(void) {

    unsigned uvar = UINT_MAX;
    uvar++;
    return uvar;
}
```

In the third statement of this function, the variable `uvar` is increased by 1. However, the value of `uvar` is the maximum unsigned integer value, so 1 plus the maximum integer value cannot be represented by an `unsigned int`. The C programming language standard does not view unsigned overflow as an error because the program automatically reduces the result by modulo the maximum value plus 1. In this example, `uvar` is reduced by modulo `UINT_MAX`. The result is `uvar = 1`.

Correction — Different Storage Type

One possible correction is to store the operation result in a larger data type. In this example, by returning an `unsigned long long` instead of an `unsigned int`, the overflow error is fixed.

```
#include <limits.h>

unsigned long long plusplus(void) {
```

```
    unsigned long long ullvar = UINT_MAX;
    ullvar++;
    return ullvar;
}
```

Unsigned integer constant overflow

Description

Unsigned integer constant overflow occurs when you assign a compile-time constant to a unsigned integer variable whose data type cannot accommodate the value. An n-bit unsigned integer holds values in the range `[0, 2^n-1]`.

For instance, `c` is an 8-bit unsigned `char` variable that cannot hold the value 256.

```
unsigned char c = 256;
```

To determine the sizes of fundamental types, Bug Finder uses your specification for `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

The C standard states that overflowing unsigned integers must be wrapped around (see, for instance, the C11 standard, section 6.2.5). However, the wrap-around behavior can be unintended and cause unexpected results.

Fix

Check if the constant value is what you intended. If the value is correct, use a wider data type for the variable.

Example - Overflowing Constant from Macro Expansion

```
#define MAX_UNSIGNED_CHAR 255
#define MAX_UNSIGNED_SHORT 65535

void main() {
    unsigned char c1 = MAX_UNSIGNED_CHAR + 1;
    unsigned short c2 = MAX_UNSIGNED_SHORT + 1;
}
```

In this example, the defect appears on the macros because at least one use of the macro causes an overflow.

Correction — Use Wider Data Type

One possible correction is to use a wider data type for the variables that overflow.

```
#define MAX_UNSIGNED_CHAR 255
#define MAX_UNSIGNED_SHORT 65535

void main() {
    unsigned short c1 = MAX_UNSIGNED_CHAR + 1;
    unsigned int c2 = MAX_UNSIGNED_SHORT + 1;
}
```

Check Information

Group: Rule 04. Integers (INT)

See Also

External Websites

INT30-C

Introduced in R2019a

CERT C: Rule INT31-C

Ensure that integer conversions do not result in lost or misinterpreted data

Description

Rule Definition

Ensure that integer conversions do not result in lost or misinterpreted data.

Examples

Integer conversion overflow

Description

Integer conversion overflow occurs when converting an integer to a smaller integer type. If the variable does not have enough bytes to represent the original value, the conversion overflows.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Integer conversion overflows result in undefined behavior.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variables in the overflowing computation acquire their current values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

You can fix the defect by:

- Using a bigger data type for the result of the conversion so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

In general, avoid conversions to smaller integer types.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Converting from `int` to `char`

```
char convert(void) {

    int num = 1000000;

    return (char)num;
}
```

In the return statement, the integer variable `num` is converted to a `char`. However, an 8-bit or 16-bit character cannot represent 1000000 because it requires at least 20 bits. So the conversion operation overflows.

Correction — Change Conversion Type

One possible correction is to convert to a different integer type that can represent the entire number.

```
long convert(void) {

    int num = 1000000;

    return (long)num;
}
```

Call to memset with unintended value

Description

Call to memset with unintended value occurs when Polyspace Bug Finder detects a use of the `memset` or `wmemset` function with possibly incorrect arguments.

`void *memset (void *ptr, int value, size_t num)` fills the first `num` bytes of the memory block that `ptr` points to with the specified `value`. If the argument `value` is incorrect, the memory block is initialized with an unintended value.

The unintended initialization can occur in the following cases.

Issue	Risk	Possible Fix
The second argument is `'0'` instead of `0` or `'\0'`.	The ASCII value of character `'0'` is `48` (decimal), `0x30` (hexadecimal), `069` (octal) but not `0` (or `'\0'`) .	If you want to initialize with `'0'`, use one of the ASCII values. Otherwise, use `0` or `'\0'`.
The second and third arguments are probably reversed. For instance, the third argument is a literal and the second argument is not a literal.	If the order is reversed, a memory block of unintended size is initialized with incorrect arguments.	Reverse the order of the arguments.
The second argument cannot be represented in a byte.	If the second argument cannot be represented in a byte, and you expect each byte of a memory block to be filled with that argument, the initialization does not occur as intended.	Apply a bit mask to the argument to produce a wrapped or truncated result that can be represented in a byte. When you apply a bit mask, make sure that it produces an expected result. For instance, replace `memset(a, -13, sizeof(a))` with `memset(a, (-13) & 0xFF, sizeof(a))`.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Value Cannot Be Represented in a Byte

```
#include <string.h>

#define SIZE 32
void func(void) {
    char buf[SIZE];
    int c = -2;
    memset(buf, (char)c, sizeof(buf));
}
```

In this example, `(char)c` cannot be represented in a byte.

Correction — Apply Cast

One possible correction is to apply a cast so that the result can be represented in a byte. However, check that the result of the cast is an acceptable initialization value.

```
#include <string.h>

#define SIZE 32
void func(void) {
    char buf[SIZE   ];
    int c = -2;
    memset(buf, (unsigned char)c, sizeof(buf));
}
```

Sign change integer conversion overflow

Description

Sign change integer conversion overflow occurs when converting an unsigned integer to a signed integer. If the variable does not have enough bytes to represent both the original constant and the sign bit, the conversion overflows.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Convert from `unsigned char` to `char`

```
char sign_change(void) {
    unsigned char count = 255;

    return (char)count;
}
```

In the return statement, the unsigned character variable `count` is converted to a signed character. However, `char` has 8 bits, 1 for the sign of the constant and 7 to represent the number. The conversion operation overflows because 255 uses 8 bits.

Correction — Change conversion types

One possible correction is using a larger integer type. By using an `int`, there are enough bits to represent the sign and the number value.

```
int sign_change(void) {
    unsigned char count = 255;
```

```
    return (int)count;
}
```

Tainted sign change conversion

Description

Tainted sign change conversion looks for values from unsecure sources that are converted, implicitly or explicitly, from signed to unsigned values.

For example, functions that use `size_t` as arguments implicitly convert the argument to an unsigned integer. Some functions that implicitly convert `size_t` are:

```
bcmp
memcpy
memmove
strncmp
strncpy
calloc
malloc
memalign
```

Risk

If you convert a small negative number to unsigned, the result is a large positive number. The large positive number can create security vulnerabilities. For example, if you use the unsigned value in:

- Memory size routines — causes allocating memory issues.
- String manipulation routines — causes buffer overflow.
- Loop boundaries — causes infinite loops.

Fix

To avoid converting unsigned negative values, check that the value being converted is within an acceptable range. For example, if the value represents a size, validate that the value is not negative and less than the maximum value size.

Example - Set Memory Value with Size Argument

```
#include <stdlib.h>
#include <string.h>
```

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

void bug_taintedsignchange(int size) {
    char str[SIZE128] = "";
    if (size<SIZE128) {
        memset(str, 'c', size);
    }
}
```

In this example, a `char` buffer is created and filled using `memset`. The size argument to `memset` is an input argument to the function.

The call to `memset` implicitly converts `size` to unsigned integer. If `size` is a large negative number, the absolute value could be too large to represent as an integer, causing a buffer overflow.

Correction — Check Value of `size`

One possible correction is to check if `size` is inside the valid range. This correction checks if `size` is greater than zero and less than the buffer size before calling `memset`.

```
#include <stdlib.h>
#include <string.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

void corrected_taintedsignchange(int size) {
    char str[SIZE128] = "";
    if (size>0 && size<SIZE128) {
        memset(str, 'c', size);
    }
}
```

Unsigned integer conversion overflow

Description

Unsigned integer conversion overflow occurs when converting an unsigned integer to a smaller unsigned integer type. If the variable does not have enough bytes to represent the original constant, the conversion overflows.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Integer conversion overflows result in undefined behavior.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

You can fix the defect by:

- Using a bigger data type for the result of the conversion so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

In general, avoid conversions to smaller integer types.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Converting from `int` to `char`

```
unsigned char convert(void) {
    unsigned int unum = 1000000U;
```

```
    return (unsigned char)unum;
}
```

In the return statement, the unsigned integer variable `unum` is converted to an unsigned character type. However, the conversion overflows because 1000000 requires at least 20 bits. The C programming language standard does not view unsigned overflow as an error because the program automatically reduces the result by modulo the maximum value plus 1. In this example, `unum` is reduced by modulo `2^8` because a character data type can only represent `2^8-1`.

Correction — Change Conversion Type

One possible correction is to convert to a different integer type that can represent the entire number. For example, `long`.

```
unsigned long convert(void) {
    unsigned int unum = 1000000U;

    return (unsigned long)unum;
}
```

Check Information

Group: Rule 04. Integers (INT)

See Also

External Websites

INT31-C

Introduced in R2019a

CERT C: Rule INT32-C

Ensure that operations on signed integers do not result in overflow

Description

Rule Definition

Ensure that operations on signed integers do not result in overflow.

Examples

Integer overflow

Description

Integer overflow occurs when an operation on integer variables can result in values that cannot be represented by the result data type. The data type of a variable determines the number of bytes allocated for the variable storage and constrains the range of allowed values.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Integer overflows on signed integers result in undefined behavior.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variables in the overflowing computation acquire their current values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace

back using right-click options in the source code and see previous related events. See also .

You can fix the defect by:

- Using a bigger data type for the result of the operation so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

To avoid overflows in general, try one of these techniques:

- Keep integer variable values restricted to within half the range of signed integers.
- In operations that might overflow, check for conditions that can lead to the overflow and implement wrap around or saturation behavior depending on how the result of the operation is used. The result then becomes predictable and can be safely used in subsequent computations.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Addition of Maximum Integer

```
#include <limits.h>

int plusplus(void) {

    int var = INT_MAX;
    var++;
    return var;
}
```

In the third statement of this function, the variable `var` is increased by one. But the value of `var` is the maximum integer value, so an `int` cannot represent one plus the maximum integer value.

Correction — Different Storage Type

One possible correction is to change data types. Store the result of the operation in a larger data type (Note that on a 32-bit machine, `int` and `long` has the same size). In this

example, on a 32-bit machine, by returning a `long long` instead of an `int`, the overflow error is fixed.

```
#include <limits.h>

long long plusplus(void) {

    long long lvar = INT_MAX;
    lvar++;
    return lvar;
}
```

Tainted division operand

Description

Tainted division operand detects division operations where one or both of the integer operands is from an unsecure source.

Risk

- If the numerator is the minimum possible value and the denominator is `-1`, your division operation overflows because the result cannot be represented by the current variable size.
- If the denominator is zero, your division operation fails possibly causing your program to crash.

These risks can be used to execute arbitrary code. This code is usually outside the scope of a program's implicit security policy.

Fix

Before performing the division, validate the values of the operands. Check for denominators of `0` or `-1`, and numerators of the minimum integer value.

Example - Division of Function Arguments

```
extern void print_int(int);

int taintedintdivision(int usernum, int userden) {
    int r =  usernum/userden;
    print_int(r);
```

```
    return r;
}
```

This example function divides two argument variables, then prints and returns the result. The argument values are unknown and can cause division by zero or integer overflow.

Correction — Check Values

One possible correction is to check the values of the numerator and denominator before performing the division.

```
#include "limits.h"

extern void print_int(int);

int taintedintdivision(int usernum, int userden) {
    int r = 0;
    if (userden!=0 && !(usernum=INT_MIN && userden==-1)) {
        r = usernum/userden;
    }
    print_int(r);
    return r;
}
```

Tainted modulo operand

Description

Tainted modulo operand checks the operands of remainder `%` operations. Bug Finder flags modulo operations with one or more tainted operands.

Risk

- If the second remainder operand is zero, your remainder operation fails, causing your program to crash.
- If the second remainder operand is `-1`, your remainder operation can overflow if the remainder operation is implemented based on the division operation that can overflow.
- If one of the operands is negative, the operation result is uncertain. For C89, the modulo operation is not standardized, so the result from negative operands is implementation-defined.

These risks can be exploited by attackers to gain access to your program or the target in general.

Fix

Before performing the modulo operation, validate the values of the operands. Check the second operand for values of `0` and `-1`. Check both operands for negative values.

Example - Modulo with Function Arguments

```
extern void print_int(int);

int taintedintmod(int userden) {
    int rem =  128%userden;
    print_int(rem);
    return rem;
}
```

In this example, the function performs a modulo operation by using an input argument. The argument is not checked before calculating the remainder for values that can crash the program, such as 0 and -1.

Correction — Check Operand Values

One possible correction is to check the values of the operands before performing the modulo operation. In this corrected example, the modulo operation continues only if the second operand is greater than zero.

```
extern void print_int(int);

int taintedintmod(int userden) {
    int rem = 0;
    if (userden > 0) {
        rem = 128 % userden;
    }
    print_int(rem);
    return rem;
}
```

Check Information

Group: Rule 04. Integers (INT)

See Also

External Websites

INT32-C

Introduced in R2019a

CERT C: Rule INT33-C

Ensure that division and remainder operations do not result in divide-by-zero errors

Description

Rule Definition

Ensure that division and remainder operations do not result in divide-by-zero errors.

Examples

Integer division by zero

Description

Integer division by zero occurs when the denominator of a division or modulo operation can be a zero-valued integer.

Risk

A division by zero can result in a program crash.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the denominator variable acquires a zero value. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

It is a good practice to check for zero values of a denominator before division and handle the error. Instead of performing the division directly:

```
res = num/den;
```

use a library function that handles zero values of the denominator before performing the division:

```
res = div(num, den);
```

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Dividing an Integer by Zero

```
int fraction(int num)
{
    int denom = 0;
    int result = 0;

    result = num/denom;

    return result;
}
```

A division by zero error occurs at `num/denom` because `denom` is zero.

Correction — Check Before Division

```
int fraction(int num)
{
    int denom = 0;
    int result = 0;

    if (denom != 0)
        result = num/denom;

    return result;
}
```

Before dividing, add a test to see if the denominator is zero, checking before division occurs. If `denom` is always zero, this correction can produce a dead code defect in your Polyspace results.

Correction — Change Denominator

One possible correction is to change the denominator value so that `denom` is not zero.

```
int fraction(int num)
{
    int denom = 2;
    int result = 0;

    result = num/denom;

    return result;
}
```

Example - Modulo Operation with Zero

```
int mod_arr(int input)
{
    int arr[5];
    for(int i = 0; i < 5; i++)
    {
        arr[i] = input % i;
    }

    return arr[0]+arr[1]+arr[2]+arr[3]+arr[4];
}
```

In this example, Polyspace flags the modulo operation as a division by zero. Because modulo is inherently a division operation, the divisor (right hand argument) cannot be zero. The modulo operation uses the `for` loop index as the divisor. However, the `for` loop starts at zero, which cannot be an iterator.

Correction — Check Divisor Before Operation

One possible correction is checking the divisor before the modulo operation. In this example, see if the index `i` is zero before the modulo operation.

```
int mod_arr(int input)
{
    int arr[5];
    for(int i = 0; i < 5; i++)
    {
        if(i != 0)
        {
             arr[i] = input % i;
        }
        else
        {
```

```
            arr[i] = input;
        }
    }

    return arr[0]+arr[1]+arr[2]+arr[3]+arr[4];
}
```

Correction — Change Divisor

Another possible correction is changing the divisor to a nonzero integer. In this example, add one to the index before the `%` operation to avoid dividing by zero.

```
int mod_arr(int input)
{
    int arr[5];
    for(int i = 0; i < 5; i++)
    {
         arr[i] = input % (i+1);
    }

    return arr[0]+arr[1]+arr[2]+arr[3]+arr[4];
}
```

Tainted division operand

Description

Tainted division operand detects division operations where one or both of the integer operands is from an unsecure source.

Risk

- If the numerator is the minimum possible value and the denominator is `-1`, your division operation overflows because the result cannot be represented by the current variable size.
- If the denominator is zero, your division operation fails possibly causing your program to crash.

These risks can be used to execute arbitrary code. This code is usually outside the scope of a program's implicit security policy.

Fix

Before performing the division, validate the values of the operands. Check for denominators of `0` or `-1`, and numerators of the minimum integer value.

Example - Division of Function Arguments

```
extern void print_int(int);

int taintedintdivision(int usernum, int userden) {
    int r =  usernum/userden;
    print_int(r);
    return r;
}
```

This example function divides two argument variables, then prints and returns the result. The argument values are unknown and can cause division by zero or integer overflow.

Correction — Check Values

One possible correction is to check the values of the numerator and denominator before performing the division.

```
#include "limits.h"

extern void print_int(int);

int taintedintdivision(int usernum, int userden) {
    int r = 0;
    if (userden!=0 && !(usernum=INT_MIN && userden==-1)) {
        r = usernum/userden;
    }
    print_int(r);
    return r;
}
```

Tainted modulo operand

Description

Tainted modulo operand checks the operands of remainder `%` operations. Bug Finder flags modulo operations with one or more tainted operands.

Risk

- If the second remainder operand is zero, your remainder operation fails, causing your program to crash.
- If the second remainder operand is `-1`, your remainder operation can overflow if the remainder operation is implemented based on the division operation that can overflow.
- If one of the operands is negative, the operation result is uncertain. For C89, the modulo operation is not standardized, so the result from negative operands is implementation-defined.

These risks can be exploited by attackers to gain access to your program or the target in general.

Fix

Before performing the modulo operation, validate the values of the operands. Check the second operand for values of `0` and `-1`. Check both operands for negative values.

Example - Modulo with Function Arguments

```
extern void print_int(int);

int taintedintmod(int userden) {
    int rem =  128%userden;
    print_int(rem);
    return rem;
}
```

In this example, the function performs a modulo operation by using an input argument. The argument is not checked before calculating the remainder for values that can crash the program, such as 0 and -1.

Correction — Check Operand Values

One possible correction is to check the values of the operands before performing the modulo operation. In this corrected example, the modulo operation continues only if the second operand is greater than zero.

```
extern void print_int(int);

int taintedintmod(int userden) {
    int rem = 0;
    if (userden > 0) {
```

```
        rem = 128 % userden;
    }
    print_int(rem);
    return rem;
}
```

Check Information

Group: Rule 04. Integers (INT)

See Also

External Websites

INT33-C

Introduced in R2019a

CERT C: Rule INT34-C

Do not shift an expression by a negative number of bits or by greater than or equal to the number of bits that exist in the operand

Description

Rule Definition

Do not shift an expression by a negative number of bits or by greater than or equal to the number of bits that exist in the operand.

Examples

Shift of a negative value

Description

Shift of a negative value occurs when a bit-wise shift is used on a variable that can have negative values.

Risk

Shifts on negative values overwrite the sign bit that identifies a number as negative. The shift operation can result in unexpected values.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variable being shifted acquires negative values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

To fix the defect, check for negative values before the bit-wise shift operation and perform appropriate error handling.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Shifting a negative variable

```
int shifting(int val)
{
    int res = -1;
    return res << val;
}
```

In the return statement, the variable `res` is shifted a certain number of bits to the left. However, because `res` is negative, the shift might overwrite the sign bit.

Correction — Change the Data Type

One possible correction is to change the data type of the shifted variable to unsigned. This correction eliminates the sign bit, so left shifting does not change the sign of the variable.

```
int shifting(int val)
{
    unsigned int res = -1;
    return res << val;
}
```

Shift operation overflow

Description

Shift operation overflow occurs when a shift operation can result in values that cannot be represented by the result data type. The data type of a variable determines the number of bytes allocated for the variable storage and constrains the range of allowed values.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Shift operation overflows can result in undefined behavior.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variables in the shift operation acquire their current values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

You can fix the defect by:

- Using a bigger data type for the result of the shift operation so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Left Shift of Integer

```
int left_shift(void) {

    int foo = 33;
    return 1 << foo;
}
```

In the return statement of this function, bit-wise shift operation is performed shifting 1 `foo` bits to the left. However, an `int` has only 32 bits, so the range of the shift must be between 0 and 31. Therefore, this shift operation causes an overflow.

Correction — Different storage type

One possible correction is to store the shift operation result in a larger data type. In this example, by returning a `long long` instead of an `int`, the overflow defect is fixed.

```
long long left_shift(void) {

    int foo = 33;
    return 1LL << foo;
}
```

Check Information

Group: Rule 04. Integers (INT)

See Also

External Websites

INT34-C

Introduced in R2019a

CERT C: Rule INT35-C

Use correct integer precisions

Description

Rule Definition

Use correct integer precisions.

Examples

Integer precision exceeded

Description

Integer precision exceeded occurs when an integer expression uses the integer size in an operation that exceeds the integer precision. On some architectures, the size of an integer in memory can include sign and padding bits. On these architectures, the integer size is larger than the precision which is just the number of bits that represent the value of the integer.

Risk

Using the size of an integer in an operation on the integer precision can result in integer overflow, wrap around, or unexpected results. For instance, an unsigned integer can be stored in memory in 64 bits, but uses only 48 bits to represent its value. A 56 bits left-shift operation on this integer is undefined behavior.

Assuming that the size of an integer is equal to its precision can also result in program portability issues between different architectures.

Fix

Do not use the size of an integer instead of its precision. To determine the integer precision, implement a precision computation routine or use a builtin function such as `__builtin_popcount()`.

Example - Using Size of `unsigned int` for Left Shift Operation

```
#include <limits.h>

unsigned int func(unsigned int exp)
{
    if (exp >= sizeof(unsigned int) * CHAR_BIT) {
        /* Handle error */
    }
    return 1U << exp;
}
```

In this example, the function uses a left shift operation to return the value of 2 raised to the power of `exp`. The operation shifts the bits of `1U` by `exp` positions to the left. The `if` statement ensures that the operation does not shift the bits by a number of positions `exp` greater than the size of an `unsigned int`. However, if `unsigned int` contains padding bits, the value returned by `sizeof()` is larger than the precision of `unsigned int`. As a result, some values of `exp` might be too large, and the shift operation might be undefined behavior.

Correction — Implement Function to Compute Precision of `unsigned int`

One possible correction is to implement a function `popcount()` that computes the precision of `unsigned int` by counting the number of set bits.

```
#include <stddef.h>
#include <stdint.h>
#include <limits.h>

size_t popcount(uintmax_t);
#define PRECISION(umax_value) popcount(umax_value)


unsigned int func(unsigned int exp)
{
    if (exp >= PRECISION(UINT_MAX)) {
        /* Handle error */
    }
```

```
    return 1 << exp;
}



size_t popcount(uintmax_t num)
{
    size_t precision = 0;
    while (num != 0) {
        if (num % 2 == 1) {
            precision++;
        }
        num >>= 1;
    }
    return precision;
}
```

Check Information

Group: Rule 04. Integers (INT)

See Also

External Websites

INT35-C

Introduced in R2019a

CERT C: Rule INT36-C

Converting a pointer to integer or integer to pointer

Description

Rule Definition

Converting a pointer to integer or integer to pointer.

Examples

Unsafe conversion between pointer and integer

Description

Unsafe conversion between pointer and integer checks for pointer to integer and integer to pointers conversions. If you convert between a pointer, `intptr_t`, or `uintprt_t` and an integer type, such as `enum`, `ptrdiff_t`, or `pid_t`, Polyspace raises a defect.

Risk

The mapping between pointers and integers is not always consistent with the addressing structure of the environment.

Converting from pointers to integers can create:

- Truncated or out of range integer values.
- Invalid integer types.

Converting from integers to pointers can create:

- Misaligned pointers or misaligned objects.
- Invalid pointer addresses.

Fix

Where possible, avoid pointer-to-integer or integer-to-pointer conversions. If you want to convert a `void` pointer to an integer, so that you do not change the value, use types:

- C99 — `intptr_t` or `uintptr_t`
- C90 — `size_t` or `ssize_t`

Example - Integer to Pointer Conversions

```
unsigned int *badintptrcast(void)
{
    unsigned int *ptr0 = (unsigned int *)0xdeadbeef;
    char *ptr1 = (char *)0xdeadbeef;
    return (unsigned int *)(ptr0 - (unsigned int *)ptr1);
}
```

In this example, there are three conversions, two unsafe conversions and one safe conversion. The first conversion of `0xdeadbeef` to `unsigned int*` causes alignment issues for the pointer. The second conversion of `0xdeadbeef` to `char *` is safe because there are no alignment issues for `char`. The third conversion in the return casts `ptrdiff_t` to a pointer. This pointer might or might not point to an invalid address.

Correction — Use `intptr_t`

One possible correction is to use `intptr_t` types to store the pointer address `0xdeadbeef`. Also, you can change the second pointer to an integer offset so that there is no longer a conversion from `ptrdiff_t` to a pointer.

```
#include <stdint.h>

unsigned int *badintptrcast(void)
{
    intptr_t iptr0 = (intptr_t)0xdeadbeef;
    int offset = 0;
    return (unsigned int *)(iptr0 - offset);
}
```

Check Information

Group: Rule 04. Integers (INT)

See Also

External Websites

INT36-C

Introduced in R2019a

Rule 05. Floating Point (FLP)

CERT C: Rule FLP30-C

Do not use floating-point variables as loop counters

Description

Rule Definition

Do not use floating-point variables as loop counters.

Examples

Use of float variable as loop counter

Description

The issue occurs when a loop counter has a floating type.

If the `for` index is a variable symbol, Polyspace checks that it is not a float.

Risk

When using a floating-point loop counter, accumulation of rounding errors can result in a mismatch between the expected and actual number of iterations. This rounding error can happen when a loop step that is not a power of the floating point radix is rounded to a value that can be represented by a float.

Even if a loop with a floating-point loop counter appears to behave correctly on one implementation, it can give a different number of iteration on another implementation.

Example - `for` Loop Counters

```
int main(void){
    unsigned int counter = 0u;
    int result = 0;
    float foo;
```

```
    // Float loop counters
    for(float foo = 0.0f; foo < 1.0f; foo +=0.001f){
        /* Non-compliant - counter = 1000 at the end of the loop */
        ++counter;
    }

    float fff = 0.0f;
    for(fff = 0.0f; fff <12.0f; fff += 1.0f){    /* Non-compliant*/
        result++;
    }

    // Integer loop count
    for(unsigned int count = 0u; count < 1000u; ++count){ /* Compliant */
        foo = (float) count * 0.001f;
    }
}
```

In this example, the three `for` loops show three different loop counters. The first and second `for` loops use float variables as loop counters, and therefore are not compliant. The third loop uses the integer `count` as the loop counter. Even though `count` is used as a float inside the loop, the variable remains an integer when acting as the loop index. Therefore, this `for` loop is compliant.

Example - `while` Loop Counters

```
int main(void){
    unsigned int u32a;
    float foo;

    foo = 0.0f;
    while (foo < 1.0f){
        foo += 0.001f;  /* Non-compliant - foo used as a loop counter */
    }

    foo = read_float32();
    do{
        u32a = read_u32();
    }while( ((float)u32a - foo) > 10.0f );
                        /* Compliant - foo doesn't change in the loop */
                        /*  so cannot be a counter */
    return 1;
}
```

This example shows two `while` loops both of which use `foo` in the `while`-loop conditions.

The first `while` loop uses `foo` in the condition and inside the loop. Because `foo` changes, floating-point rounding errors can cause unexpected behavior.

The second `while` loop does not use `foo` inside the loop, but does use `foo` inside the `while`-condition. So `foo` is not the loop counter. The integer `u32a` is the loop counter because it changes inside the loop and is part of the while condition. Because `u32a` is an integer, the rounding error issue is not a concern, making this `while` loop compliant.

Check Information

Group: Rule 05. Floating Point (FLP)

See Also

External Websites

FLP30-C

Introduced in R2019a

CERT C: Rule FLP32-C

Prevent or detect domain and range errors in math functions

Description

Rule Definition

Prevent or detect domain and range errors in math functions.

Examples

Invalid use of standard library floating point routine

Description

Invalid use of standard library floating point routine occurs when you use invalid arguments with a floating point function from the standard library. This defect picks up:

- Rounding and absolute value routines

  ```
  ceil, fabs, floor, fmod
  ```

- Fractions and division routines

  ```
  fmod, modf
  ```

- Exponents and log routines

  ```
  frexp, ldexp, sqrt, pow, exp, log, log10
  ```

- Trigonometry function routines

  ```
  cos, sin, tan, acos, asin, atan, atan2, cosh, sinh, tanh, acosh,
  asinh, atanh
  ```

Risk

Domain errors on standard library floating point functions result in implementation-defined values. If you use the function return value in subsequent computations, you can see unexpected results.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the function argument acquires invalid values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

It is a good practice to handle for domain errors before using a standard library floating point function. For instance, before calling the `acos` function, check if the argument is in [-1.0, 1.0] and handle the error.

See examples of fixes below.

If you do not want to fix the issue, for instance, when you handle infinities in your code, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Arc Cosine Operation

```
#include <math.h>

double arccosine(void) {
    double degree = 5.0;
    return acos(degree);
}
```

The input value to `acos` must be in the interval `[-1,1]`. This input argument, `degree`, is outside this range.

Correction — Change Input Argument

One possible correction is to change the input value to fit the specified range. In this example, change the input value from degrees to radians to fix this defect.

```
#include <math.h>
```

```
double arccosine(void) {
    double degree = 5.0;
    double radian = degree * 3.14159 / 180.;
    return acos(radian);
}
```

Check Information

Group: Rule 05. Floating Point (FLP)

See Also

External Websites

FLP32-C

Introduced in R2019a

CERT C: Rule FLP34-C

Ensure that floating-point conversions are within range of the new type

Description

Rule Definition

Ensure that floating-point conversions are within range of the new type.

Examples

Float conversion overflow

Description

Float conversion overflow occurs when converting a floating point number to a smaller floating point data type. If the variable does not have enough memory to represent the original number, the conversion overflows.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Overflows can result in unpredictable values from computations. The result can be infinity or the maximum finite value depending on the rounding mode used in the implementation. If you use the result of an overflowing conversion in subsequent computations and do not account for the overflow, you can see unexpected results.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variable being converted acquires its current value You can implement the fix on any event in the

sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

You can fix the defect by:

- Using a bigger data type for the result of the conversion so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

In general, avoid conversions to smaller floating point types.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Converting from `double` to `float`

```
float convert(void) {

    double diam = 1e100;
    return (float)diam;
}
```

In the return statement, the variable `diam` of type double (64 bits) is converted to a variable of type float (32 bits). However, the value 1^100 requires more than 32 bits to be precisely represented.

Check Information

Group: Rule 05. Floating Point (FLP)

See Also

External Websites

FLP34-C

Introduced in R2019a

CERT C: Rule FLP36-C

Preserve precision when converting integral values to floating-point type

Description

Rule Definition

Preserve precision when converting integral values to floating-point type.

Examples

Precision loss in integer to float conversion

Description

Precision loss from integer to float conversion occurs when you cast an integer value to a floating-point type that cannot represent the original integer value.

For instance, the `long int` value `1234567890L` is too large for a variable of type `float` .

Risk

If the floating-point type cannot represent the integer value, the behavior is undefined (see C11 standard, 6.3.1.4, paragraph 2). For instance, least significant bits of the variable value can be dropped leading to unexpected results.

Fix

Convert to a floating-point type that can represent the integer value.

For instance, if the `float` data type cannot represent the integer value, use the `double` data type instead.

When writing a function that converts an integer to floating point type, before the conversion, check if the integer value can be represented in the floating-point type. For

instance, `DBL_MANT_DIG * log2(FLT_RADIX)` represents the number of base-2 digits in the type `double`. Before conversion to the type `double`, check if this number is greater than or equal to the precision of the integer that you are converting. To determine the precision of an integer `num`, use this code:

```
size_t precision = 0;
while (num != 0) {
   if (num % 2 == 1) {
     precision++;
   }
   num >>= 1;
}
```

Some implementations provide a builtin function to determine the precision of an integer. For instance, GCC provides the function `__builtin_popcount`.

Example - Conversion of Large Integer to Floating-Point Type

```
#include <stdio.h>

int main(void) {
  long int big = 1234567890L;
  float approx = big;
  printf("%ld\n", (big - (long int)approx));
  return 0;
}
```

In this example, the `long int` variable `big` is converted to `float`.

Correction — Use a Wider Floating-Point Type

One possible correction is to convert to the `double` data type instead of `float`.

```
#include <stdio.h>

int main(void) {
  long int big = 1234567890L;
  double approx = big;
  printf("%ld\n", (big - (long int)approx));
  return 0;
}
```

Check Information

Group: Rule 05. Floating Point (FLP)

See Also

External Websites

FLP36-C

Introduced in R2019a

CERT C: Rule FLP37-C

Do not use object representations to compare floating-point values

Description

Rule Definition

Do not use object representations to compare floating-point values.

Examples

Memory comparison of float-point values

Description

Memory comparison of float-point values occurs when you compare the object representation of floating-point values or the object representation of structures containing floating-point members. When you use the functions `memcmp`, `bcmp`, or `wmemcmp` to perform the bit pattern comparison, the defect is raised.

Risk

The object representation of floating-point values uses specific bit patterns to encode those values. Floating-point values that are equal, for instance `-0.0` and `0.0` in the IEC 60559 standard, can have different bit patterns in their object representation. Similarly, floating-point values that are not equal can have the same bit pattern in their object representation.

Fix

When you compare structures containing floating-point members, compare the structure members individually.

To compare two floating-point values, use the == or != operators. If you follow a standard that discourages the use of these operators, such as MISRA, ensure that the difference between the floating-point values is within an acceptable range.

Example - Using `memcmp` to Compare Structures with Floating-Point Members

```
#include <string.h>

typedef struct {
    int i;
    float f;
} myStruct;

extern void initialize_Struct(myStruct *);

int func_cmp(myStruct *s1, myStruct *s2) {
/* Comparison between structures containing
* floating-point members */
    return memcmp
        ((const void *)s1, (const void *)s2, sizeof(myStruct));
}

void func(void) {
    myStruct s1, s2;
    initialize_Struct(&s1);
    initialize_Struct(&s2);
    (void)func_cmp(&s1, &s2);
}
```

In this example, `func_cmp()` calls `memcmp()` to compare the object representations of structures `s1` and `s2`. The comparison might be inaccurate because the structures contain floating-point members.

Correction — Compare Structure Members Individually

One possible correction is to compare the structure members individually and to ensure that the difference between the floating-point values is within an acceptable range defined by ESP.

```
 #include <string.h>

typedef struct {
    int i;
    float f;
```

```
} myStruct;

extern void initialize_Struct(myStruct *);

#define ESP 0.00001

int func_cmp(myStruct *s1, myStruct *s2) {

/*Structure members are compared individually */
    return ((s1->i == s2->i) &&
            (fabsf(s1->f - s2->f) <= ESP));
}

void func(void) {
    myStruct s1, s2;
    initialize_Struct(&s1);
    initialize_Struct(&s2);
    (void)func_cmp(&s1, &s2);
}
```

Check Information

Group: Rule 05. Floating Point (FLP)

See Also

External Websites

FLP37-C

Introduced in R2019a

Rule 06. Arrays (ARR)

CERT C: Rule ARR30-C

Do not form or use out-of-bounds pointers or array subscripts

Description

Rule Definition

Do not form or use out-of-bounds pointers or array subscripts.

Examples

Array access out of bounds

Description

Array access out of bounds occurs when an array index falls outside the range `[0...array_size-1]` during array access.

Risk

Accessing an array outside its bounds is undefined behavior. You can read an unpredictable value or try to access a location that is not allowed and encounter a segmentation fault.

Fix

The fix depends on the root cause of the defect. For instance, you accessed an array inside a loop and one of these situations happened:

- The upper bound of the loop is too large.
- You used an array index that is the same as the loop index instead of being one less than the loop index.

To fix the issue, you have to modify the loop bound or the array index.

Another reason why an array index can exceed array bounds is a prior conversion from signed to unsigned integers. The conversion can result in a wrap around of the index value, eventually causing the array index to exceed the array bounds.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Array Access Out of Bounds Error

```
#include <stdio.h>

void fibonacci(void)
{
    int i;
    int fib[10];

    for (i = 0; i < 10; i++)
       {
        if (i < 2)
            fib[i] = 1;
         else
            fib[i] = fib[i-1] + fib[i-2];
       }

    printf("The 10-th Fibonacci number is %i .\n", fib[i]);
    /* Defect: Value of i is greater than allowed value of 9 */
}
```

The array `fib` is assigned a size of 10. An array index for `fib` has allowed values of `[0,1,2,...,9]`. The variable `i` has a value 10 when it comes out of the `for`-loop. Therefore, the `printf` statement attempts to access `fib[10]` through `i`.

Correction — Keep Array Index Within Array Bounds

One possible correction is to print `fib[i-1]` instead of `fib[i]` after the `for`-loop.

```
#include <stdio.h>
```

```
void fibonacci(void)
{
   int i;
   int fib[10];

   for (i = 0; i < 10; i++)
    {
        if (i < 2)
            fib[i] = 1;
        else
            fib[i] = fib[i-1] + fib[i-2];
    }

    /* Fix: Print fib[9] instead of fib[10] */
    printf("The 10-th Fibonacci number is %i .\n", fib[i-1]);
}
```

The `printf` statement accesses `fib[9]` instead of `fib[10]`.

Pointer access out of bounds

Description

Pointer access out of bounds occurs when a pointer is dereferenced outside its bounds.

When a pointer is assigned an address, a block of memory is associated with the pointer. You cannot access memory beyond that block using the pointer.

Risk

Dereferencing a pointer outside its bounds is undefined behavior. You can read an unpredictable value or try to access a location that is not allowed and encounter a segmentation fault.

Fix

The fix depends on the root cause of the defect. For instance, you dereferenced a pointer inside a loop and one of these situations happened:

- The upper bound of the loop is too large.
- You used pointer arithmetic to advance the pointer with an incorrect value for the pointer increment.

To fix the issue, you have to modify the loop bound or the pointer increment value.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Pointer access out of bounds error

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
   {
    ptr++;
    *ptr=i;
    /* Defect: ptr out of bounds for i=9 */
   }

 return(arr);
}
```

`ptr` is assigned the address `arr` that points to a memory block of size `10*sizeof(int)`. In the `for`-loop, `ptr` is incremented 10 times. In the last iteration of the loop, `ptr` points outside the memory block assigned to it. Therefore, it cannot be dereferenced.

Correction — Check Pointer Stays Within Bounds

One possible correction is to reverse the order of increment and dereference of `ptr`.

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
     {
```

```
      /* Fix: Dereference pointer before increment */
      *ptr=i;
      ptr++;
     }

 return(arr);
}
```

After the last increment, even though `ptr` points outside the memory block assigned to it, it is not dereferenced more.

Array access with tainted index

Description

Array access with tainted index detects reading or writing to an array by using a tainted index that has not been validated.

Risk

The index might be outside the valid array range. If the tainted index is outside the array range, it can cause:

- Buffer underflow/underwrite — writing to memory before the beginning of the buffer.
- Buffer overflow — writing to memory after the end of a buffer.
- Over-reading a buffer — accessing memory after the end of the targeted buffer.
- Under-reading a buffer, or accessing memory before the beginning of the targeted buffer.

An attacker can use an invalid read or write operation create to problems in your program.

Fix

Before using the index to access the array, validate the index value to make sure that it is inside the array range.

Example - Use Index to Return Buffer Value

```
#define SIZE100 100
extern int tab[SIZE100];
```

```
int taintedarrayindex(int num) {
    return tab[num];
}
```

In this example, the index `num` accesses the array `tab`. The function does not check to see if `num` is inside the range of `tab`.

Correction — Check Range Before Use

One possible correction is to check that `num` is in range before using it.

```
#define SIZE100 100
extern int tab[SIZE100];

int taintedarrayindex(int num) {
    if (num >= 0 && num < SIZE100) {
           return tab[num];
    } else {
        return -9999;
    }
}
```

Use of tainted pointer

Description

Use of tainted pointer defect is raised when:

- Tainted NULL pointer — the pointer is not validated against NULL.
- Tainted size pointer — the size of the memory zone that a pointer points to is not validated.

Note On a single pointer, your code can have instances of **Use of tainted pointer**, **Pointer dereference with tainted offset**, and **Tainted NULL or non-null-terminated string**. Bug Finder raises only the first tainted pointer defect that it finds.

Risk

An attacker can give your program a pointer that points to unexpected memory locations. If the pointer is dereferenced to write, the attacker can:

- Modify the state variables of a critical program.
- Cause your program to crash.
- Execute unwanted code.

If the pointer is dereferenced to read, the attacker can:

- Read sensitive data.
- Cause your program to crash.
- Modify a program variable to an unexpected value.

Fix

Avoid use of pointers from external sources.

Alternatively, if you trust the external source, sanitize the pointer before dereference. In a separate sanitization function:

- Check that the pointer is not NULL.
- Check the size of the memory location (if possible). This second check validates whether the size of the data the pointer points to matches the size your program expects.

The defect still appears in the body of the sanitization function. However, if you use a sanitization function, instead of several occurrences, the defect appears only once. You can justify the defect and hide it in later reviews by using code annotations. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Function That Dereferences an External Pointer

```
void taintedptr(int* p, int i) {
    *p = i;
}
```

In this example, the pointer `*p` is passed as an argument, and the value is changed. The pointer can be null or point to unknown memory, which can be vulnerable.

Correction — Avoid Use of External Pointers

One possible correction is to avoid pointers from external sources.

```
int *taintedptr(int i) {
    /* Use heap memory allocated in the application */
```

```
    int *p = (int *)malloc(sizeof (int));
    if (p != NULL) { /* Check for success */
        *p = i;
    }
return p;
}
```

Correction — Check Pointer

Another possible correction is to sanitize the pointer before using it. This example uses a second function to check if the pointer is null and can be dereferenced.

```
#include <stdlib.h>

int* sanitize_ptr(int* p) {
    int* res = NULL;
    if (p && *p) { /* Tainted pointer detected here, used as "firewall" */
        /* Pointer is not null and dereference ok */
        res = p;
    }
    return res;
}
void taintedptr(int* p, int i) {
    p = sanitize_ptr(p);
    if (p) {
        *p = i;
    }
}
```

Pointer dereference with tainted offset

Description

Pointer dereference with tainted offset detects pointer dereferencing, either reading or writing, using an offset variable from an unknown or unsecure source.

This check focuses on dynamically allocated buffers. For static buffer offsets, see `Array access with tainted index`.

Risk

The index might be outside the valid array range. If the tainted index is outside the array range, it can cause:

- Buffer underflow/underwrite, or writing to memory before the beginning of the buffer.
- Buffer overflow, or writing to memory after the end of a buffer.
- Over reading a buffer, or accessing memory after the end of the targeted buffer.
- Under-reading a buffer, or accessing memory before the beginning of the targeted buffer.

An attacker can use an invalid read or write to compromise your program.

Fix

Validate the index before you use the variable to access the pointer. Check to make sure that the variable is inside the valid range and does not overflow.

Example - Dereference Pointer Array

```
#include <stdlib.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};
extern void read_pint(int*);

int taintedptroffset(int i) {
    int* pint = (int*)calloc(SIZE10, sizeof(int));
    int c = 0;
    if(pint) {
        /* Filling array */
        read_pint(pint);
        c = pint[i];
        free(pint);
    }
    return c;
}
```

In this example, the function initializes an integer pointer `pint`. The pointer is dereferenced using the input index `i`. The value of `i` could be outside the pointer range, causing an out-of-range error.

Correction — Check Index Before Dereference

One possible correction is to validate the value of the index. If the index is inside the valid range, continue with the pointer dereferencing.

```
#include <stdlib.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};
extern void read_pint(int*);

int taintedptroffset(int i) {
    int* pint = (int*)calloc(SIZE10, sizeof(int));
    int c = 0;
    if (pint) {
        /* Filling array */
        read_pint(pint);
        if (i>0 && i<SIZE10) {
            c = pint[i];
        }
        free(pint);
    }
    return c;
}
```

Check Information

Group: Rule 06. Arrays (ARR)

See Also

External Websites

ARR30-C

Introduced in R2019a

CERT C: Rule ARR32-C

Ensure size arguments for variable length arrays are in a valid range

Description

Rule Definition

Ensure size arguments for variable length arrays are in a valid range.

Examples

Memory allocation with tainted size

Description

Memory allocation with tainted size checks memory allocation functions, such as `calloc` or `malloc`, for size arguments from unsecured sources.

Risk

Uncontrolled memory allocation can cause your program to request too much system memory. This consequence can lead to a crash due to an out-of-memory condition, or assigning too many resources.

Fix

Before allocating memory, check the value of your arguments to check that they do not exceed the bounds.

Example - Allocate Memory Using Input Argument

```
#include "stdlib.h"

int* bug_taintedmemoryallocsize(size_t size) {
```

```
    int* p = (int*)malloc(size);
    return p;
}
```

In this example, `malloc` allocates `size` amount of memory for the pointer `p`. `size` is an outside variable, so could be any size value. If the size is larger than the amount of memory you have available, your program could crash.

Correction — Check Size of Memory to be Allocated

One possible correction is to check the size of the memory that you want to allocate before performing the `malloc` operation. This example checks to see if the size is positive and less than the maximum size.

```
#include "stdlib.h"

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int* corrected_taintedmemoryallocsize(int size) {
    int* p = NULL;
    if (size>0 && size<SIZE128) {          /* Fix: Check entry range before use */
        p = (int*)malloc((unsigned int)size);
    }
    return p;
}
```

Tainted size of variable length array

Description

Tainted size of variable length array detects variable length arrays (VLA) whose size is from an unsecure source.

Risk

If an attacker changed the size of your VLA to an unexpected value, it can cause your program to crash or behave unexpectedly.

If the size is non-positive, the behavior of the VLA is undefined. Your program does not perform as expected.

If the size is unbounded, the VLA can cause memory exhaustion or stack overflow.

Fix

Validate your VLA size to make sure that it is positive and less than a maximum value.

Example - Input Argument Used as Size of VLA

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int taintedvlasize(int size) {

    int tabvla[size];
    int res = 0;
    for (int i=0 ; i<SIZE10 ; ++i) {
        tabvla[i] = i*i;
        res += tabvla[i];
    }
    return res;
}
```

In this example, a variable length array size is based on an input argument. Because this input argument value is not checked, the size may be negative or too large.

Correction — Check VLA Size

One possible correction is to check the size variable before creating the variable length array. This example checks if the size is larger than 10 and less than 100, before creating the VLA

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int taintedvlasize(int size) {
```

```
    int res = 0;
    if (size>SIZE10 && size<SIZE100) {
        int tabvla[size];
        for (int i=0 ; i<SIZE10 ; ++i) {
            tabvla[i] = i*i;
            res += tabvla[i];
        }
    }
    return res;
}
```

Check Information

Group: Rule 06. Arrays (ARR)

See Also

External Websites

ARR32-C

Introduced in R2019a

CERT C: Rule ARR36-C

Do not subtract or compare two pointers that do not refer to the same array

Description

Rule Definition

Do not subtract or compare two pointers that do not refer to the same array.

Examples

Subtraction or comparison between pointers to different arrays

Description

Subtraction or comparison between pointers to different arrays occurs when you subtract or compare pointers that are null or that point to elements in different arrays. The relational operators for the comparison are >, <, >=, and <=.

Risk

When you subtract two pointers to elements in the same array, the result is the difference between the subscripts of the two array elements. Similarly, when you compare two pointers to array elements, the result is the positions of the pointers relative to each other. If the pointers are null or point to different arrays, a subtraction or comparison operation is undefined. If you use the subtraction result as a buffer index, it can cause a buffer overflow.

Fix

Before you subtract or use relational operators to compare pointers to array elements, check that they are non-null and that they point to the same array.

Example - Subtraction Between Pointers to Elements in Different Arrays

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define SIZE20 20

size_t func(void)
{
    int nums[SIZE20];
    int end;
    int *next_num_ptr = nums;
    size_t free_elements;
    /* Increment next_num_ptr as array fills */

    /* Subtraction operation is undefined unless array nums
    is adjacent to variable end in memory. */
    free_elements = &end - next_num_ptr;
    return free_elements;
}
```

In this example, the array `nums` is incrementally filled. Pointer subtraction is then used to determine how many free elements remain. Unless `end` points to a memory location one past the last element of `nums`, the subtraction operation is undefined.

Correction — Subtract Pointers to the Same Array

Subtract the pointer to the last element that was filled from the pointer to the last element in the array.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define SIZE20 20

size_t func(void)
{
    int nums[SIZE20];
    int *next_num_ptr = nums;
    size_t free_elements;
```

```
    /* Increment next_num_ptr as array fills */

    /* Subtraction operation involves pointers to the same array. */
    free_elements = &(nums[SIZE20 - 1]) - next_num_ptr;

    return free_elements + 1;
}
```

Check Information

Group: Rule 06. Arrays (ARR)

See Also

External Websites

ARR36-C

Introduced in R2019a

CERT C: Rule ARR37-C

Do not add or subtract an integer to a pointer to a non-array object

Description

Rule Definition

Do not add or subtract an integer to a pointer to a non-array object.

Examples

Invalid assumptions about memory organization

Description

Invalid assumptions about memory organization occurs when you compute the address of a variable in the stack by adding or subtracting from the address of another non-array variable.

Risk

When you compute the address of a variable in the stack by adding or subtracting from the address of another variable, you assume a certain memory organization. If your assumption is incorrect, accessing the computed address can be invalid.

Fix

Do not perform an access that relies on assumptions about memory organization.

Example - Reliance on Memory Organization

```
void func(void) {
    int var1 = 0x00000011, var2;
    *(&var1 + 1) = 0;
}
```

In this example, the programmer relies on the assumption that `&var1 + 1` provides the address of `var2`. Therefore, an **Invalid assumptions about memory organization** appears on the + operation. In addition, a **Pointer access out of bounds** error also appears on the dereference.

Correction — Do Not Rely on Memory Organization

One possible correction is not perform direct computation on addresses to access separately declared variables.

Check Information

Group: Rule 06. Arrays (ARR)

See Also

External Websites

ARR37-C

Introduced in R2019a

CERT C: Rule ARR38-C

Guarantee that library functions do not form invalid pointers

Description

Rule Definition

Guarantee that library functions do not form invalid pointers.

Examples

Mismatch between data length and size

Description

Mismatch between data length and size looks for memory copying functions such as `memcpy`, `memset`, or `memmove`. If you do not control the length argument and data buffer argument properly, Bug Finder raises a defect.

Risk

If an attacker can manipulate the data buffer or length argument, the attacker can cause buffer overflow by making the actual data size smaller than the length.

This mismatch in length allows the attacker to copy memory past the data buffer to a new location. If the extra memory contains sensitive information, the attacker can now access that data.

This defect is similar to the SSL Heartbleed bug.

Fix

When copying or manipulating memory, compute the length argument directly from the data so that the sizes match.

Example - Copy Buffer of Data

```
#include <stdlib.h>
#include <string.h>

typedef struct buf_mem_st {
    char *data;
    size_t max;     /* size of buffer */
} BUF_MEM;

extern BUF_MEM beta;

int cpy_data(BUF_MEM *alpha)
{
    BUF_MEM *os = alpha;
    int num, length;

    if (alpha == 0x0) return 0;
    num = 0;

    length = *(unsigned short *)os->data;
    memcpy(&(beta.data[num]), os->data + 2, length);

    return(1);
}
```

This function copies the buffer `alpha` into a buffer `beta`. However, the `length` variable is not related to `data+2`.

Correction — Check Buffer Length

One possible correction is to check the length of your buffer against the maximum value minus 2. This check ensures that you have enough space to copy the data to the `beta` structure.

```
#include <stdlib.h>
#include <string.h>

typedef struct buf_mem_st {
    char *data;
    size_t max;     /* size of buffer */
} BUF_MEM;

extern BUF_MEM beta;
```

```
int cpy_data(BUF_MEM *alpha)
{
    BUF_MEM *os = alpha;
    int num, length;

    if (alpha == 0x0) return 0;
    num = 0;

    length = *(unsigned short *)os->data;
    if (length<(os->max -2)) {
        memcpy(&(beta.data[num]), os->data + 2, length);
    }

    return(1);

}
```

Invalid use of standard library memory routine

Description

Invalid use of standard library memory routine occurs when a memory library function is called with invalid arguments. For instance, the `memcpy` function copies to an array that cannot accommodate the number of bytes copied.

Risk

Use of a memory library function with invalid arguments can result in issues such as buffer overflow.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Invalid Use of Standard Library Memory Routine Error

```
#include <string.h>
#include <stdio.h>

char* Copy_First_Six_Letters(void)
 {
  char str1[10],str2[5];

  printf("Enter string:\n");
  scanf("%s",str1);

  memcpy(str2,str1,6);
  /* Defect: Arguments of memcpy invalid: str2 has size < 6 */

  return str2;
 }
```

The size of string `str2` is 5, but six characters of string `str1` are copied into `str2` using the `memcpy` function.

Correction — Call Function with Valid Arguments

One possible correction is to adjust the size of `str2` so that it accommodates the characters copied with the `memcpy` function.

```
#include <string.h>
#include <stdio.h>

char* Copy_First_Six_Letters(void)
 {
  /* Fix: Declare str2 with size 6 */
  char str1[10],str2[6];

  printf("Enter string:\n");
  scanf("%s",str1);

  memcpy(str2,str1,6);
  return str2;
 }
```

Possible misuse of sizeof

Description

Possible misuse of sizeof occurs when Polyspace Bug Finder detects possibly unintended results from the use of `sizeof` operator. For instance:

- You use the `sizeof` operator on an array parameter name, expecting the array size. However, the array parameter name by itself is a pointer. The `sizeof` operator returns the size of that pointer.
- You use the `sizeof` operator on an array element, expecting the array size. However, the operator returns the size of the array element.
- The size argument of certain functions such as `strncmp` or `wcsncpy` is incorrect because you used the `sizeof` operator earlier with possibly incorrect expectations. For instance:
  - In a function call `strncmp(string1, string2, num)`, `num` is obtained from an incorrect use of the `sizeof` operator on a pointer.
  - In a function call `wcsncpy(destination, source, num)`, `num` is the not the number of wide characters but a size in bytes obtained by using the `sizeof` operator. For instance, you use `wcsncpy(destination, source, sizeof(destination) - 1)` instead of `wcsncpy(destination, source, (sizeof(desintation)/sizeof(wchar_t)) - 1)`.

Risk

Incorrect use of the `sizeof` operator can cause the following issues:

- If you expect the `sizeof` operator to return array size and use the return value to constrain a loop, the number of loop runs are smaller than what you expect.
- If you use the return value of `sizeof` operator to allocate a buffer, the buffer size is smaller than what you require. Insufficient buffer can lead to resultant weaknesses such as buffer overflows.
- If you use the return value of `sizeof` operator incorrectly in a function call, the function does not behave as you expect.

Fix

Possible fixes are:

- Do not use the `sizeof` operator on an array parameter name or array element to determine array size.

  The best practice is to pass the array size as a separate function parameter and use that parameter in the function body.
- Use the `sizeof` operator carefully to determine the number argument of functions such as `strncmp` or `wcsncpy`. For instance, for wide string functions such as `wcsncpy`, use the number of wide characters as argument instead of the number of bytes.

Example - `sizeof` Used Incorrectly to Determine Array Size

```
#define MAX_SIZE 1024

void func(int a[MAX_SIZE]) {
    int i;

    for (i = 0; i < sizeof(a)/sizeof(int); i++)    {
        a[i] = i + 1;
    }
}
```

In this example, `sizeof(a)` returns the size of the pointer `a` and not the array size.

Correction — Determine Array Size in Another Way

One possible correction is to use another means to determine the array size.

```
#define MAX_SIZE 1024

void func(int a[MAX_SIZE]) {
    int i;

    for (i = 0; i < MAX_SIZE; i++)    {
        a[i] = i + 1;
    }
}
```

Buffer overflow from incorrect string format specifier

Description

Buffer overflow from incorrect string format specifier occurs when the format specifier argument for functions such as `sscanf` leads to an overflow or underflow in the memory buffer argument.

Risk

If the format specifier specifies a precision that is greater than the memory buffer size, an overflow occurs. Overflows can cause unexpected behavior such as memory corruption.

Fix

Use a format specifier that is compatible with the memory buffer size.

Example - Memory Buffer Overflow

```
#include <stdio.h>

void func (char *str[]) {
    char buf[32];
    sscanf(str[1], "%33c", buf);
}
```

In this example, `buf` can contain 32 `char` elements. Therefore, the format specifier `%33c` causes a buffer overflow.

Correction — Use Smaller Precision in Format Specifier

One possible correction is to use a smaller precision in the format specifier.

```
#include <stdio.h>

void func (char *str[]) {
    char buf[32];
    sscanf(str[1], "%32c", buf);
}
```

Invalid use of standard library string routine

Description

Invalid use of standard library string routine occurs when a string library function is called with invalid arguments.

Risk

The risk depends on the type of invalid arguments. For instance, using the `strcpy` function with a source argument larger than the destination argument can result in buffer overflows.

Fix

The fix depends on the standard library function involved in the defect. In some cases, you can constrain the function arguments before the function call. For instance, if the `strcpy` function:

```
char * strcpy(char * destination, const char* source)
```

tries to copy too many bytes into the destination argument compared to the available buffer, constrain the source argument before the call to `strcpy`. In some cases, you can use an alternative function to avoid the error. For instance, instead of `strcpy`, you can use `strncpy` to control the number of bytes copied. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Invalid Use of Standard Library String Routine Error

```
#include <string.h>
#include <stdio.h>

char* Copy_String(void)
{
 char *res;
 char gbuffer[5],text[20]="ABCDEFGHIJKL";

 res=strcpy(gbuffer,text);
 /* Error: Size of text is less than gbuffer */
```

```
  return(res);
 }
```

The string `text` is larger in size than `gbuffer`. Therefore, the function `strcpy` cannot copy `text` into `gbuffer`.

Correction — Use Valid Arguments

One possible correction is to declare the destination string `gbuffer` with equal or larger size than the source string `text`.

```
#include <string.h>
 #include <stdio.h>

 char* Copy_String(void)
 {
  char *res;
  /*Fix: gbuffer has equal or larger size than text */
  char gbuffer[20],text[20]="ABCDEFGHIJKL";

  res=strcpy(gbuffer,text);

  return(res);
 }
```

Destination buffer overflow in string manipulation

Description

Destination buffer overflow in string manipulation occurs when certain string manipulation functions write to their destination buffer argument at an offset greater than the buffer size.

For instance, when calling the function `sprintf(char* buffer, const char* format)`, you use a constant string `format` of greater size than `buffer`.

Risk

Buffer overflow can cause unexpected behavior such as memory corruption or stopping your system. Buffer overflow also introduces the risk of code injection.

Fix

One possible solution is to use alternative functions to constrain the number of characters written. For instance:

- If you use `sprintf` to write formatted data to a string, use `snprintf`, `_snprintf` or `sprintf_s` instead to enforce length control. Alternatively, use `asprintf` to automatically allocate the memory required for the destination buffer.
- If you use `vsprintf` to write formatted data from a variable argument list to a string, use `vsnprintf` or `vsprintf_s` instead to enforce length control.
- If you use `wcscpy` to copy a wide string, use `wcsncpy`, `wcslcpy`, or `wcscpy_s` instead to enforce length control.

Another possible solution is to increase the buffer size.

Example - Buffer Overflow in `sprintf` Use

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";

    sprintf(buffer, fmt_string);
}
```

In this example, `buffer` can contain 20 `char` elements but `fmt_string` has a greater size.

Correction — Use `snprintf` Instead of `sprintf`

One possible correction is to use the `snprintf` function to enforce length control.

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";

    snprintf(buffer, 20, fmt_string);
}
```

Destination buffer underflow in string manipulation

Description

Destination buffer underflow in string manipulation occurs when certain string manipulation functions write to their destination buffer argument at a negative offset from the beginning of the buffer.

For instance, for the function `sprintf(char* buffer, const char* format)`, you obtain the `buffer` from an operation `buffer = (char*)arr; ... buffer += offset;`. `arr` is an array and `offset` is a negative value.

Risk

Buffer underflow can cause unexpected behavior such as memory corruption or stopping your system. Buffer underflow also introduces the risk of code injection.

Fix

If the destination buffer argument results from pointer arithmetic, see if you are decrementing a pointer. Fix the pointer decrement by modifying either the original value before decrement or the decrement value.

Example - Buffer Underflow in `sprintf` Use

```
#include <stdio.h>
#define offset -2

void func(void) {
    char buffer[20];
    char *fmt_string ="Text";

    sprintf(&buffer[offset], fmt_string);
}
```

In this example, `&buffer[offset]` is at a negative offset from the memory allocated to `buffer`.

Correction — Change Pointer Decrementer

One possible correction is to change the value of `offset`.

```
#include <stdio.h>
#define offset 2
```

```
void func(void) {
    char buffer[20];
    char *fmt_string ="Text";

    sprintf(&buffer[offset], fmt_string);
}
```

Check Information

Group: Rule 06. Arrays (ARR)

See Also

External Websites

ARR38-C

Introduced in R2019a

CERT C: Rule ARR39-C

Do not add or subtract a scaled integer to a pointer

Description

Rule Definition

Do not add or subtract a scaled integer to a pointer.

Examples

Incorrect pointer scaling

Description

Incorrect pointer scaling occurs when Polyspace Bug Finder considers that you are ignoring the implicit scaling in pointer arithmetic.

For instance, the defect can occur in the following situations.

Situation	Risk	Possible Fix
You use the `sizeof` operator in arithmetic operations on a pointer.	The `sizeof` operator returns the size of a data type in number of bytes. Pointer arithmetic is already implicitly scaled by the size of the data type of the pointed variable. Therefore, the use of `sizeof` in pointer arithmetic produces unintended results.	Do not use `sizeof` operator in pointer arithmetic.

Situation	Risk	Possible Fix
You perform arithmetic operations on a pointer, and then apply a cast.	Pointer arithmetic is implicitly scaled. If you do not consider this implicit scaling, casting the result of a pointer arithmetic produces unintended results.	Apply the cast before the pointer arithmetic.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Use of `sizeof` Operator

```
void func(void) {
    int arr[5] = {1,2,3,4,5};
    int *ptr = arr;

    int value_in_position_2 = *(ptr + 2*(sizeof(int)));
}
```

In this example, the operation `2*(sizeof(int))` returns twice the size of an `int` variable in bytes. However, because pointer arithmetic is implicitly scaled, the number of bytes by which `ptr` is offset is `2*(sizeof(int))*(sizeof(int))`.

In this example, the incorrect scaling shifts `ptr` outside the bounds of the array. Therefore, a **Pointer access out of bounds** error appears on the * operation.

Correction — Remove `sizeof` Operator

One possible correction is to remove the `sizeof` operator.

```
void func(void) {
    int arr[5] = {1,2,3,4,5};
```

```
    int *ptr = arr;

    int value_in_position_2 = *(ptr + 2);
}
```

Example - Cast Following Pointer Arithmetic

```
int func(void) {
    int x = 0;
    char r = *(char *)(&x + 1);
    return r;
}
```

In this example, the operation `&x + 1` offsets `&x` by `sizeof(int)`. Following the operation, the resulting pointer points outside the allowed buffer. When you dereference the pointer, a **Pointer access out of bounds** error appears on the * operation.

Correction — Apply Cast Before Pointer Arithmetic

If you want to access the second byte of `x`, first cast `&x` to a `char*` pointer and then perform the pointer arithmetic. The resulting pointer is offset by `sizeof(char)` bytes and still points within the allowed buffer, whose size is `sizeof(int)` bytes.

```
int func(void) {
    int x = 0;
    char r = *((char *)(&x )+ 1);
    return r;
}
```

Pointer access out of bounds

Description

Pointer access out of bounds occurs when a pointer is dereferenced outside its bounds.

When a pointer is assigned an address, a block of memory is associated with the pointer. You cannot access memory beyond that block using the pointer.

Risk

Dereferencing a pointer outside its bounds is undefined behavior. You can read an unpredictable value or try to access a location that is not allowed and encounter a segmentation fault.

Fix

The fix depends on the root cause of the defect. For instance, you dereferenced a pointer inside a loop and one of these situations happened:

- The upper bound of the loop is too large.
- You used pointer arithmetic to advance the pointer with an incorrect value for the pointer increment.

To fix the issue, you have to modify the loop bound or the pointer increment value.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Pointer access out of bounds error

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
   {
    ptr++;
    *ptr=i;
    /* Defect: ptr out of bounds for i=9 */
   }

 return(arr);
}
```

`ptr` is assigned the address `arr` that points to a memory block of size `10*sizeof(int)`. In the `for`-loop, `ptr` is incremented 10 times. In the last iteration of the loop, `ptr` points outside the memory block assigned to it. Therefore, it cannot be dereferenced.

Correction — Check Pointer Stays Within Bounds

One possible correction is to reverse the order of increment and dereference of `ptr`.

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
     {
      /* Fix: Dereference pointer before increment */
      *ptr=i;
      ptr++;
     }

 return(arr);
}
```

After the last increment, even though `ptr` points outside the memory block assigned to it, it is not dereferenced more.

Possible misuse of sizeof

Description

Possible misuse of sizeof occurs when Polyspace Bug Finder detects possibly unintended results from the use of `sizeof` operator. For instance:

- You use the `sizeof` operator on an array parameter name, expecting the array size. However, the array parameter name by itself is a pointer. The `sizeof` operator returns the size of that pointer.
- You use the `sizeof` operator on an array element, expecting the array size. However, the operator returns the size of the array element.
- The size argument of certain functions such as `strncmp` or `wcsncpy` is incorrect because you used the `sizeof` operator earlier with possibly incorrect expectations. For instance:
  - In a function call `strncmp(string1, string2, num)`, `num` is obtained from an incorrect use of the `sizeof` operator on a pointer.
  - In a function call `wcsncpy(destination, source, num)`, `num` is the not the number of wide characters but a size in bytes obtained by using the `sizeof`

operator. For instance, you use `wcsncpy(destination, source, sizeof(destination) - 1)` instead of `wcsncpy(destination, source, (sizeof(desintation)/sizeof(wchar_t)) - 1)`.

Risk

Incorrect use of the `sizeof` operator can cause the following issues:

- If you expect the `sizeof` operator to return array size and use the return value to constrain a loop, the number of loop runs are smaller than what you expect.
- If you use the return value of `sizeof` operator to allocate a buffer, the buffer size is smaller than what you require. Insufficient buffer can lead to resultant weaknesses such as buffer overflows.
- If you use the return value of `sizeof` operator incorrectly in a function call, the function does not behave as you expect.

Fix

Possible fixes are:

- Do not use the `sizeof` operator on an array parameter name or array element to determine array size.

  The best practice is to pass the array size as a separate function parameter and use that parameter in the function body.
- Use the `sizeof` operator carefully to determine the number argument of functions such as `strncmp` or `wcsncpy`. For instance, for wide string functions such as `wcsncpy`, use the number of wide characters as argument instead of the number of bytes.

Example - `sizeof` Used Incorrectly to Determine Array Size

```
#define MAX_SIZE 1024

void func(int a[MAX_SIZE]) {
    int i;

    for (i = 0; i < sizeof(a)/sizeof(int); i++)    {
        a[i] = i + 1;
    }
}
```

In this example, `sizeof(a)` returns the size of the pointer `a` and not the array size.

Correction — Determine Array Size in Another Way

One possible correction is to use another means to determine the array size.

```
#define MAX_SIZE 1024

void func(int a[MAX_SIZE]) {
    int i;

    for (i = 0; i < MAX_SIZE; i++)    {
        a[i] = i + 1;
    }
}
```

Check Information

Group: Rule 06. Arrays (ARR)

See Also

External Websites

ARR39-C

Introduced in R2019a

Rule 07. Characters and Strings (STR)

CERT C: Rule STR30-C

Do not attempt to modify string literals

Description

Rule Definition

Do not attempt to modify string literals.

Examples

Writing to const qualified object

Description

Writing to `const` qualified object occurs when you do one of the following:

- Use a `const`-qualified object as the destination of an assignment.
- Pass a `const`-qualified object to a function that modifies the argument.

For instance, the defect can occur in the following situations:

- You pass a `const`-qualified object as first argument of one of the following functions:
  - `mkstemp`
  - `mkostemp`
  - `mkostemps`
  - `mkdtemp`
- You pass a `const`-qualified object as the destination argument of one of the following functions:
  - `strcpy`
  - `strncpy`

  - `strcat`
  - `memset`
- You perform a write operation on a `const`-qualified object.

Risk

The risk depends upon the modifications made to the `const`-qualified object.

Situation	Risk
Passing to `mkstemp`, `mkostemp`, `mkostemps`, `mkdtemp`, and so on.	These functions replace the last six characters of their first argument with a string. Therefore, they expect a modifiable `char` array as their first argument.
Passing to `strcpy`, `strncpy`, `strcat`, `memset` and so on.	These functions modify their destination argument. Therefore, they expect a modifiable `char` array as their destination argument.
Writing to the object	The `const` qualifier implies an agreement that the value of the object will not be modified. By writing to a `const`-qualified object, you break the agreement. The result of the operation is undefined.

Fix

The fix depends on the modification made to the `const`-qualified object.

Situation	Fix
Passing to `mkstemp`, `mkostemp`, `mkostemps`, `mkdtemp`, and so on.	Pass a non-`const` object as first argument of the function.
Passing to `strcpy`, `strncpy`, `strcat`, `memset` and so on.	Pass a non-`const` object as destination argument of the function.
Writing to the object	Perform the write operation on a non-`const` object.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Writing to `const`-Qualified Object

```
#include <string.h>

const char* buffer = "abcdeXXXXXXX";

void func(char* string) {
    char *ptr = (char*)strchr(buffer,'X');
    if(ptr)
        strcpy(ptr,string);
}
```

In this example, because `buffer` is `const`-qualified, `strchr(buffer,'X')` returns a `const`-qualified `char*` pointer. When this `char*` pointer is used as the destination argument of `strcpy`, a **Writing to const qualified object** error appears.

Correction — Copy `const`-Qualified Object to Non-`const` Object

One possible correction is to assign the constant string to a non-`const` object and use the non-`const` object as destination argument of `strchr`.

```
#include <string.h>

char buffer[] = "abcdeXXXXXXX";

void func(char* string) {
    char *ptr = (char*)strchr(buffer,'X');
    if(ptr)
        strcpy(ptr,string);
}
```

Check Information

Group: Rule 07. Characters and Strings (STR)

See Also

External Websites

STR30-C

Introduced in R2019a

CERT C: Rule STR31-C

Guarantee that storage for strings has sufficient space for character data and the null terminator

Description

Rule Definition

Guarantee that storage for strings has sufficient space for character data and the null terminator.

Examples

Use of dangerous standard function

Description

The **Use of dangerous standard function** check highlights uses of functions that are inherently dangerous or potentially dangerous given certain circumstances. The following table lists possibly dangerous functions, the risks of using each function, and what function to use instead.

Dangerous Function	Risk Level	Safer Function
`gets`	Inherently dangerous — You cannot control the length of input from the console.	`fgets`
`cin`	Inherently dangerous — You cannot control the length of input from the console.	Avoid or prefaces calls to `cin` with `cin.width`.

Dangerous Function	Risk Level	Safer Function
`strcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`strncpy`
`stpcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`stpncpy`
`lstrcpy` or `StrCpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`StringCbCopy`, `StringCchCopy`, `strncpy`, `strcpy_s`, or `strlcpy`
`strcat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`strncat`, `strlcat`, or `strcat_s`
`lstrcat` or `StrCat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`StringCbCat`, `StringCchCat`, `strncay`, `strcat_s`, or `strlcat`
`wcpcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`wcpncpy`
`wcscat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`wcsncat`, `wcslcat`, or `wcncat_s`
`wcscpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`wcsncpy`

Dangerous Function	Risk Level	Safer Function
`sprintf`	Possibly dangerous — If the output length depends on unknown lengths or values, buffer overflow can occur.	`snprintf`
`vsprintf`	Possibly dangerous — If the output length depends on unknown lengths or values, buffer overflow can occur.	`vsnprintf`

Risk

These functions can cause buffer overflow, which attackers can use to infiltrate your program.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Using `sprintf`

```
#include <stdio.h>
#include <string.h>
#include <iostream>

#define BUFF_SIZE 128


int dangerous_func(char *str)
{
    char dst[BUFF_SIZE];
    int r = 0;
```

```
    if (sprintf(dst, "%s", str) == 1)
    {
        r += 1;
        dst[BUFF_SIZE-1] = '\0';
    }

    return r;
}
```

This example function uses `sprintf` to copy the string `str` to `dst`. However, if `str` is larger than the buffer, `sprintf` can cause buffer overflow.

Correction — Use `snprintf` with Buffer Size

One possible correction is to use `snprintf` instead and specify a buffer size.

```
#include <stdio.h>
#include <string.h>
#include <iostream>

#define BUFF_SIZE 128


int dangerous_func(char *str)
{
    char dst[BUFF_SIZE];
    int r = 0;

    if (snprintf(dst, sizeof(dst), "%s", str) == 1)
    {
        r += 1;
        dst[BUFF_SIZE-1] = '\0';
    }

    return r;
}
```

Missing null in string array

Description

Missing null in string array occurs when a string does not have enough space to terminate with a null character `'\0'`.

This defect applies only for projects in C.

Risk

A buffer overflow can occur if you copy a string to an array without assuming the implicit null terminator.

Fix

If you initialize a character array with a literal, avoid specifying the array bounds.

```
char three[]  = "THREE";
```

The compiler automatically allocates space for a null terminator. In the preceding example, the compiler allocates sufficient space for five characters and a null terminator.

If the issue occurs after initialization, you might have to increase the size of the array by one to account for the null terminator.

In certain circumstances, you might want to initialize the character array with a sequence of characters instead of a string. In this situation, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Array size is too small

```
void countdown(int i)
{
    static char one[5]   = "ONE";
    static char two[5]   = "TWO";
    static char three[5] = "THREE";
}
```

The character array `three` has a size of 5 and 5 characters `'T'`, `'H'`, `'R'`, `'E'`, and `'E'`. There is no room for the null character at the end because `three` is only five bytes large.

Correction — Increase Array Size

One possible correction is to change the array size to allow for the five characters plus a null character.

```
void countdown(int i)
{
    static char one[5]   = "ONE";
    static char two[5]   = "TWO";
```

```
    static char three[6] = "THREE";
}
```

Correction — Change Initialization Method

One possible correction is to initialize the string by leaving the array size blank. This initialization method allocates enough memory for the five characters and a terminating-null character.

```
void countdown(int i)
{
    static char one[5]   = "ONE";
    static char two[5]   = "TWO";
    static char three[]  = "THREE";
}
```

Buffer overflow from incorrect string format specifier

Description

Buffer overflow from incorrect string format specifier occurs when the format specifier argument for functions such as `sscanf` leads to an overflow or underflow in the memory buffer argument.

Risk

If the format specifier specifies a precision that is greater than the memory buffer size, an overflow occurs. Overflows can cause unexpected behavior such as memory corruption.

Fix

Use a format specifier that is compatible with the memory buffer size.

Example - Memory Buffer Overflow

```
#include <stdio.h>

void func (char *str[]) {
    char buf[32];
    sscanf(str[1], "%33c", buf);
}
```

In this example, `buf` can contain 32 `char` elements. Therefore, the format specifier `%33c` causes a buffer overflow.

Correction — Use Smaller Precision in Format Specifier

One possible correction is to use a smaller precision in the format specifier.

```
#include <stdio.h>

void func (char *str[]) {
    char buf[32];
    sscanf(str[1], "%32c", buf);
}
```

Destination buffer overflow in string manipulation

Description

Destination buffer overflow in string manipulation occurs when certain string manipulation functions write to their destination buffer argument at an offset greater than the buffer size.

For instance, when calling the function `sprintf(char* buffer, const char* format)`, you use a constant string `format` of greater size than `buffer`.

Risk

Buffer overflow can cause unexpected behavior such as memory corruption or stopping your system. Buffer overflow also introduces the risk of code injection.

Fix

One possible solution is to use alternative functions to constrain the number of characters written. For instance:

- If you use `sprintf` to write formatted data to a string, use `snprintf`, `_snprintf` or `sprintf_s` instead to enforce length control. Alternatively, use `asprintf` to automatically allocate the memory required for the destination buffer.
- If you use `vsprintf` to write formatted data from a variable argument list to a string, use `vsnprintf` or `vsprintf_s` instead to enforce length control.
- If you use `wcscpy` to copy a wide string, use `wcsncpy`, `wcslcpy`, or `wcscpy_s` instead to enforce length control.

Another possible solution is to increase the buffer size.

Example - Buffer Overflow in `sprintf` Use

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";

    sprintf(buffer, fmt_string);
}
```

In this example, `buffer` can contain 20 `char` elements but `fmt_string` has a greater size.

Correction — Use `snprintf` Instead of `sprintf`

One possible correction is to use the `snprintf` function to enforce length control.

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";

    snprintf(buffer, 20, fmt_string);
}
```

Tainted NULL or non-null-terminated string

Description

Tainted NULL or non-null-terminated string looks for strings from unsecure sources that are being used in string manipulation routines that implicitly dereference the string buffer. For example, `strcpy` or `sprintf`.

Tainted NULL or non-null-terminated string raises no defect for a string returned from a call to `scanf`-family variadic functions. Similarly, no defect is raised when you pass the string with a `%s` specifier to `printf`-family variadic functions.

Note If you reference a string using the form `ptr[i]`, `*ptr`, or pointer arithmetic, Bug Finder raises a **Use of tainted pointer** defect instead. The **Tainted NULL or non-null-terminated string** defect is raised only when the pointer is used as a string.

Risk

If a string is from an unsecure source, it is possible that an attacker manipulated the string or pointed the string pointer to a different memory location.

If the string is NULL, the string routine cannot dereference the string, causing the program to crash. If the string is not null-terminated, the string routine might not know when the string ends. This error can cause you to write out of bounds, causing a buffer overflow.

Fix

Validate the string before you use it. Check that:

- The string is not NULL.
- The string is null-terminated
- The size of the string matches the expected size.

Example - Getting String from Input Argument

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128

extern void print_str(const char*);

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}
```

In this example, the string `str` is concatenated with the argument `userstr`. The value of `userstr` is unknown. If the size of `userstr` is greater than the space available, the concatenation overflows.

Correction — Validate the Data

One possible correction is to check the size of `userstr` and make sure that the string is null-terminated before using it in `strncat`. This example uses a helper function, `sansitize_str`, to validate the string. The defects are concentrated in this function.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128

extern void print_str(const char*);

int sanitize_str(char* s) {
  int res = 0;
  if (s && (strlen(s) > 0)) { // TAINTED_STRING only flagged here
    // - string is not null
    // - string has a positive and limited size
    // - TAINTED_STRING on strlen used as a firewall
    res = 1;
  }
  return res;
}

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    if (sanitize_str(userstr))
      strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  if (sanitize_str(userstr))
    strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}
```

Correction — Validate the Data

Another possible correction is to call function `errorMsg` and `warningMsg` with specific strings.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128

extern void print_str(const char*);

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}

int manageSensorValue(int sensorValue) {
  int ret = sensorValue;
  if ( sensorValue < 0 ) {
    errorMsg("sensor value should be positive");
    exit(1);
  } else if ( sensorValue > 50 ) {
    warningMsg("sensor value greater than 50 (applying threshold)...");
    sensorValue = 50;
  }

  return sensorValue;
}
```

Check Information

Group: Rule 07. Characters and Strings (STR)

See Also

External Websites

STR31-C

Introduced in R2019a

CERT C: Rule STR32-C

Do not pass a non-null-terminated character sequence to a library function that expects a string

Description

Rule Definition

Do not pass a non-null-terminated character sequence to a library function that expects a string.

Examples

Invalid use of standard library string routine

Description

Invalid use of standard library string routine occurs when a string library function is called with invalid arguments.

Risk

The risk depends on the type of invalid arguments. For instance, using the `strcpy` function with a source argument larger than the destination argument can result in buffer overflows.

Fix

The fix depends on the standard library function involved in the defect. In some cases, you can constrain the function arguments before the function call. For instance, if the `strcpy` function:

```
char * strcpy(char * destination, const char* source)
```

tries to copy too many bytes into the destination argument compared to the available buffer, constrain the source argument before the call to `strcpy`. In some cases, you can

use an alternative function to avoid the error. For instance, instead of `strcpy`, you can use `strncpy` to control the number of bytes copied.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See "Address Polyspace Results Through Bug Fixes or Comments".

Example - Invalid Use of Standard Library String Routine Error

```
#include <string.h>
#include <stdio.h>

char* Copy_String(void)
{
 char *res;
 char gbuffer[5],text[20]="ABCDEFGHIJKL";

 res=strcpy(gbuffer,text);
 /* Error: Size of text is less than gbuffer */

 return(res);
}
```

The string `text` is larger in size than `gbuffer`. Therefore, the function `strcpy` cannot copy `text` into `gbuffer`.

Correction — Use Valid Arguments

One possible correction is to declare the destination string `gbuffer` with equal or larger size than the source string `text`.

```
#include <string.h>
#include <stdio.h>

char* Copy_String(void)
{
 char *res;
 /*Fix: gbuffer has equal or larger size than text */
 char gbuffer[20],text[20]="ABCDEFGHIJKL";

 res=strcpy(gbuffer,text);

 return(res);
}
```

Tainted NULL or non-null-terminated string

Description

Tainted NULL or non-null-terminated string looks for strings from unsecure sources that are being used in string manipulation routines that implicitly dereference the string buffer. For example, `strcpy` or `sprintf`.

Tainted NULL or non-null-terminated string raises no defect for a string returned from a call to `scanf`-family variadic functions. Similarly, no defect is raised when you pass the string with a `%s` specifier to `printf`-family variadic functions.

Note If you reference a string using the form `ptr[i]`, `*ptr`, or pointer arithmetic, Bug Finder raises a **Use of tainted pointer** defect instead. The **Tainted NULL or non-null-terminated string** defect is raised only when the pointer is used as a string.

Risk

If a string is from an unsecure source, it is possible that an attacker manipulated the string or pointed the string pointer to a different memory location.

If the string is NULL, the string routine cannot dereference the string, causing the program to crash. If the string is not null-terminated, the string routine might not know when the string ends. This error can cause you to write out of bounds, causing a buffer overflow.

Fix

Validate the string before you use it. Check that:

- The string is not NULL.
- The string is null-terminated
- The size of the string matches the expected size.

Example - Getting String from Input Argument

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
```

```
#define SIZE128 128

extern void print_str(const char*);

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}
```

In this example, the string `str` is concatenated with the argument `userstr`. The value of `userstr` is unknown. If the size of `userstr` is greater than the space available, the concatenation overflows.

Correction — Validate the Data

One possible correction is to check the size of `userstr` and make sure that the string is null-terminated before using it in `strncat`. This example uses a helper function, `sansitize_str`, to validate the string. The defects are concentrated in this function.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128

extern void print_str(const char*);

int sanitize_str(char* s) {
  int res = 0;
  if (s && (strlen(s) > 0)) { // TAINTED_STRING only flagged here
    // - string is not null
    // - string has a positive and limited size
    // - TAINTED_STRING on strlen used as a firewall
    res = 1;
  }
```

```
  return res;
}

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    if (sanitize_str(userstr))
      strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  if (sanitize_str(userstr))
    strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}
```

Correction — Validate the Data

Another possible correction is to call function `errorMsg` and `warningMsg` with specific strings.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128

extern void print_str(const char*);

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}
```

```
int manageSensorValue(int sensorValue) {
  int ret = sensorValue;
  if ( sensorValue < 0 ) {
    errorMsg("sensor value should be positive");
    exit(1);
  } else if ( sensorValue > 50 ) {
    warningMsg("sensor value greater than 50 (applying threshold)...");
    sensorValue = 50;
  }

  return sensorValue;
}
```

Check Information

Group: Rule 07. Characters and Strings (STR)

See Also

External Websites

STR32-C

Introduced in R2019a

CERT C: Rule STR34-C

Cast characters to unsigned char before converting to larger integer sizes

Description

Rule Definition

Cast characters to unsigned char before converting to larger integer sizes.

Examples

Misuse of sign-extended character value

Description

Misuse of sign-extended character value occurs when you convert a signed or plain `char` data type to a wider integer data type with sign extension. You then use the resulting sign-extended value as array index, for comparison with EOF or as argument to a character-handling function.

Risk

Comparison with EOF: Suppose, your compiler implements the plain `char` type as signed. In this implementation, the character with the decimal form of 255 (–1 in two's complement form) is stored as a signed value. When you convert a `char` variable to the wider data type `int` for instance, the sign bit is preserved (sign extension). This sign extension results in the character with the decimal form 255 being converted to the integer –1, which cannot be distinguished from EOF.

Use as array index: By similar reasoning, you cannot use sign-extended plain `char` variables as array index. If the sign bit is preserved, the conversion from `char` to `int` can result in negative integers. You must use positive integer values for array index.

Argument to character-handling function: By similar reasoning, you cannot use sign-extended plain `char` variables as arguments to character-handling functions declared in

`ctype.h`, for instance, `isalpha()` or `isdigit()`. According to the C11 standard (Section 7.4), if you supply an integer argument that cannot be represented as `unsigned char` or EOF, the resulting behavior is undefined.

Fix

Before conversion to a wider integer data type, cast the signed or plain `char` value explicitly to `unsigned char`.

Example - Sign-Extended Character Value Compared with EOF

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

extern char parsed_token_buffer[20];

static int parser(char *buf)
{
    int c = EOF;
    if (buf && *buf) {
        c = *buf++;
    }
    return c;
}

void func()
{
    if (parser(parsed_token_buffer) == EOF) {
        /* Handle error */
        fatal_error();
    }
}
```

In this example, the function `parser` can traverse a string input `buf`. If a character in the string has the decimal form 255, when converted to the `int` variable `c`, its value becomes –1, which is indistinguishable from `EOF`. The later comparison with `EOF` can lead to a false positive.

Correction — Cast to `unsigned char` Before Conversion

One possible correction is to cast the plain `char` value to `unsigned char` before conversion to the wider `int` type.

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

extern char parsed_token_buffer[20];

static int parser(char *buf)
{
    int c = EOF;
    if (buf && *buf) {
        c = (unsigned char)*buf++;
    }
    return c;
}

void func()
{
    if (parser(parsed_token_buffer) == EOF) {
        /* Handle error */
        fatal_error();
    }
}
```

Check Information

Group: Rule 07. Characters and Strings (STR)

See Also

External Websites

STR34-C

Introduced in R2019a

CERT C: Rule STR37-C

Arguments to character-handling functions must be representable as an unsigned char

Description

Rule Definition

Arguments to character-handling functions must be representable as an unsigned char.

Examples

Invalid use of standard library integer routine

Description

Invalid use of standard library integer routine occurs when you use invalid arguments with an integer function from the standard library. This defect picks up:

- Character Conversion

  ```
  toupper, tolower
  ```
- Character Checks

  ```
  isalnum, isalpha, iscntrl, isdigit, isgraph, islower, isprint,
  ispunct, isspace, isupper, isxdigit
  ```
- Integer Division

  ```
  div, ldiv
  ```
- Absolute Values

  ```
  abs, labs
  ```

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If

the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Absolute Value of Large Negative

```
#include <limits.h>
#include <stdlib.h>

int absoluteValue(void) {

    int neg = INT_MIN;
    return abs(neg);
}
```

The input value to `abs` is `INT_MIN`. The absolute value of `INT_MIN` is `INT_MAX+1`. This number cannot be represented by the type `int`.

Correction — Change Input Argument

One possible correction is to change the input value to fit returned data type. In this example, change the input value to `INT_MIN+1`.

```
#include <limits.h>
#include <stdlib.h>

int absoluteValue(void) {

    int neg = INT_MIN+1;
    return abs(neg);
}
```

Check Information

Group: Rule 07. Characters and Strings (STR)

See Also

External Websites

STR37-C

Introduced in R2019a

CERT C: Rule STR38-C

Do not confuse narrow and wide character strings and functions

Description

Rule Definition

Do not confuse narrow and wide character strings and functions.

Examples

Misuse of narrow or wide character string

Description

Misuse of narrow or wide character string occurs when you pass a narrow character string to a wide string function, or a wide character string to a narrow string function.

Misuse of narrow or wide character string raises no defect on operating systems where narrow and wide character strings have the same size.

Risk

Using a narrow character string with a wide string function, or vice versa, can result in unexpected or undefined behavior.

If you pass a wide character string to a narrow string function, you can encounter these issues:

- Data truncation. If the string contains null bytes, a copy operation using `strncpy()` can terminate early.
- Incorrect string length. `strlen()` returns the number of characters of a string up to the first null byte. A wide string can have additional characters after its first null byte.

If you pass a narrow character string to a wide string function, you can encounter this issue:

- Buffer overflow. In a copy operation using `wcsncpy()`, the destination string might have insufficient memory to store the result of the copy.

Fix

Use the narrow string functions with narrow character strings. Use the wide string functions with wide character strings.

Example - Passing Wide Character Strings to `strncpy()`

```
#include <string.h>
#include <wchar.h>

void func(void)
{
    wchar_t wide_str1[]  = L"0123456789";
    wchar_t wide_str2[] =  L"0000000000";
    strncpy(wide_str2, wide_str1, 10);
}
```

In this example, `strncpy()` copies 10 wide characters from `wide_strt1` to `wide_str2`. If `wide_str1` contains null bytes, the copy operation can end prematurely and truncate the wide character string.

Correction — Use `wcsncpy()` to Copy Wide Character Strings

One possible correction is to use `wcsncpy()` to copy `wide_str1` to `wide_str2`.

```
#include <string.h>
#include <wchar.h>

void func(void)
{
    wchar_t wide_str1[]  = L"0123456789";
    wchar_t wide_str2[] =  L"0000000000";
    wcsncpy(wide_str2, wide_str1, 10);
}
```

Check Information

Group: Rule 07. Characters and Strings (STR)

See Also

External Websites

STR38-C

Introduced in R2019a

Rule 08. Memory Management (MEM)

CERT C: Rule MEM30-C

Do not access freed memory

Description

Rule Definition

Do not access freed memory.

Examples

Use of previously freed pointer

Description

Use of previously freed pointer occurs when you access a block of memory after freeing the block using the `free` function.

Risk

When a pointer is allocated dynamic memory with `malloc`, `calloc` or `realloc`, it points to a memory location on the heap. When you use the `free` function on this pointer, the associated block of memory is freed for reallocation. Trying to access this block of memory can result in unpredictable behavior or even a segmentation fault.

Fix

The fix depends on the root cause of the defect. See if you intended to free the memory later or allocate another memory block to the pointer before access.

As a good practice, after you free a memory block, assign the corresponding pointer to NULL. Before dereferencing pointers, check them for NULL values and handle the error. In this way, you are protected against accessing a freed block.

Example - Use of Previously Freed Pointer Error

```
#include <stdlib.h>
#include <stdio.h>
 int increment_content_of_address(int base_val, int shift)
   {
    int j;
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return 0;

    *pi = base_val;
    free(pi);

    j = *pi + shift;
    /* Defect: Reading a freed pointer */

    return j;
   }
```

The `free` statement releases the block of memory that `pi` refers to. Therefore, dereferencing`pi` after the `free` statement is not valid.

Correction — Free Pointer After Use

One possible correction is to free the pointer `pi` only after the last instance where it is accessed.

```
#include <stdlib.h>

int increment_content_of_address(int base_val, int shift)
{
    int j;
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return 0;

    *pi = base_val;

    j = *pi + shift;
    *pi = 0;

    /* Fix: The pointer is freed after its last use */
    free(pi);
    return j;
}
```

Check Information

Group: Rule 08. Memory Management (MEM)

See Also

External Websites

MEM30-C

Introduced in R2019a

CERT C: Rule MEM31-C

Free dynamically allocated memory when no longer needed

Description

Rule Definition

Free dynamically allocated memory when no longer needed.

Examples

Memory leak

Description

Memory leak occurs when you do not free a block of memory allocated through `malloc`, `calloc`, `realloc`, or `new`. If the memory is allocated in a function, the defect does not occur if:

- Within the function, you free the memory using `free` or `delete`.
- The function returns the pointer assigned by `malloc`, `calloc`, `realloc`, or `new`.
- The function stores the pointer in a global variable or in a parameter.

Risk

Dynamic memory allocation functions such as `malloc` allocate memory on the heap. If you do not release the memory after use, you reduce the amount of memory available for another allocation. On embedded systems with limited memory, you might end up exhausting available heap memory even during program execution.

Fix

Determine the scope where the dynamically allocated memory is accessed. Free the memory block at the end of this scope.

To free a block of memory, use the `free` function on the pointer that was used during memory allocation. For instance:

```
ptr = (int*)malloc(sizeof(int));
...
free(ptr);
```

It is a good practice to allocate and free memory in the same module at the same level of abstraction. For instance, in this example, `func` allocates and frees memory at the same level but `func2` does not.

```
void func() {
  ptr = (int*)malloc(sizeof(int));
  {
    ...
  }
  free(ptr);
}

void func2() {
  {
   ptr = (int*)malloc(sizeof(int));
   ...
  }
  free(ptr);
}
```

See CERT-C Rule MEM00-C.

Example - Dynamic Memory Not Released Before End of Function

```
#include<stdlib.h>
#include<stdio.h>

void assign_memory(void)
{
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL)
        {
         printf("Memory allocation failed");
         return;
        }


    *pi = 42;
```

```
    /* Defect: pi is not freed */
}
```

In this example, `pi` is dynamically allocated by `malloc`. The function `assign_memory` does not free the memory, nor does it return `pi`.

Correction — Free Memory

One possible correction is to free the memory referenced by `pi` using the `free` function. The `free` function must be called before the function `assign_memory` terminates

```
#include<stdlib.h>
#include<stdio.h>

void assign_memory(void)
{
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL)
        {
         printf("Memory allocation failed");
         return;
        }
    *pi = 42;

    /* Fix: Free the pointer pi*/
    free(pi);
}
```

Correction — Return Pointer from Dynamic Allocation

Another possible correction is to return the pointer `pi`. Returning `pi` allows the function calling `assign_memory` to free the memory block using `pi`.

```
#include<stdlib.h>
#include<stdio.h>

int* assign_memory(void)
{
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL)
        {
            printf("Memory allocation failed");
            return(pi);
        }
```

```
    *pi = 42;

    /* Fix: Return the pointer pi*/
    return(pi);
}
```

Example - Memory Leak with New/Delete

```
#define NULL '\0'

void initialize_arr1(void)
{
    int *p_scalar = new int(5);
}

void initialize_arr2(void)
{
    int *p_array = new int[5];
}
```

In this example, the functions create two variables, `p_scalar` and `p_array`, using the `new` keyword. However, the functions end without cleaning up the memory for these pointers. Because the functions used `new` to create these variables, you must clean up their memory by calling `delete` at the end of each function.

Correction — Add Delete

To correct this error, add a `delete` statement for every `new` initialization. If you used brackets `[]` to instantiate a variable, you must call delete with brackets as well.

```
#define NULL '\0'

void initialize_arrs(void)
{
    int *p_scalar = new int(5);
    int *p_array = new int[5];

    delete p_scalar;
    p_scalar = NULL;

    delete[] p_array;
    p_scalar = NULL;
}
```

Check Information

Group: Rule 08. Memory Management (MEM)

See Also

External Websites

MEM31-C

Introduced in R2019a

CERT C: Rule MEM33-C

Allocate and copy structures containing a flexible array member dynamically

Description

Rule Definition

Allocate and copy structures containing a flexible array member dynamically.

Examples

Misuse of structure with flexible array member

Description

Misuse of structure with flexible array member occurs when:

- You define an object with a flexible array member of unknown size at compilation time.
- You make an assignment between structures with a flexible array member without using `memcpy()` or a similar function.
- You use a structure with a flexible array member as an argument to a function and pass the argument by value.
- Your function returns a structure with a flexible array member.

A flexible array member has no array size specified and is the last element of a structure with at least two named members.

Risk

If the size of the flexible array member is not defined, it is ignored when allocating memory for the containing structure. Accessing such a structure has undefined behavior.

Fix

- Use `malloc()` or a similar function to allocate memory for a structure with a flexible array member.
- Use `memcpy()` or a similar function to copy a structure with a flexible array member.
- Pass a structure with a flexible array member as a function argument by pointer.

Example - Structure Passed By Value to Function

```
#include <stddef.h>
#include <stdlib.h>
#include <string.h>
#include <stdio.h>
#include <unistd.h>


struct example_struct
{
    size_t num;
    int data[];
};

extern void arg_by_value(struct example_struct s);

void func(void)
{
    struct example_struct *flex_struct;
    size_t i;
    size_t array_size = 4;
    /* Dynamically allocate memory for the struct */
    flex_struct = (struct example_struct *)
        malloc(sizeof(struct example_struct) + sizeof(int) * array_size);
    if (flex_struct == NULL)
    {
        /* Handle error */
    }
    /* Initialize structure */
    flex_struct->num = array_size;
    for (i = 0; i < array_size; ++i)
    {
        flex_struct->data[i] = 0;
    }
    /* Handle structure */
```

```
    /* Argument passed by value. 'data' not
    copied to passed value. */
    arg_by_value(*flex_struct);

    /* Free dynamically allocated memory */
    free(flex_struct);
}
```

In this example, `flex_struct` is passed by value as an argument to `arg_by_value`. As a result, the flexible array member data is not copied to the passed argument.

Correction — Pass Structure by Pointer to Function

To ensure that all the members of the structure are copied to the passed argument, pass `flex_struct` to `arg_by_pointer` by pointer.

```
#include <stddef.h>
#include <stdlib.h>
#include <string.h>
#include <stdio.h>
#include <unistd.h>


struct example_struct
{
    size_t num;
    int data[];
};

extern void arg_by_pointer(struct example_struct *s);

void func(void)
{
    struct example_struct *flex_struct;
    size_t i;
    size_t array_size = 4;
    /* Dynamically allocate memory for the struct */
    flex_struct = (struct example_struct *)
        malloc(sizeof(struct example_struct) + sizeof(int) * array_size);
    if (flex_struct == NULL)
    {
        /* Handler error */
    }
```

```
    /* Initialize structure */
    flex_struct->num = array_size;
    for (i = 0; i < array_size; ++i)
    {
        flex_struct->data[i] = 0;
    }
    /* Handle structure */

    /* Structure passed by pointer */
    arg_by_pointer(flex_struct);

    /* Free dynamically allocated memory */
    free(flex_struct);
}
```

Check Information

Group: Rule 08. Memory Management (MEM)

See Also

External Websites

MEM33-C

Introduced in R2019a

CERT C: Rule MEM34-C

Only free memory allocated dynamically

Description

Rule Definition

Only free memory allocated dynamically.

Examples

Invalid free of pointer

Description

Invalid free of pointer occurs when a block of memory released using the `free` function was not previously allocated using `malloc`, `calloc`, or `realloc`.

Risk

The `free` function releases a block of memory allocated on the heap. If you try to access a location on the heap that you did not allocate previously, a segmentation fault can occur.

The issue can highlight coding errors. For instance, you perhaps wanted to use the `free` function or a previous `malloc` function on a different pointer.

Fix

In most cases, you can fix the issue by removing the `free` statement. If the pointer is not allocated memory from the heap with `malloc` or `calloc`, you do not need to free the pointer. You can simply reuse the pointer as required.

If the issue highlights a coding error such as use of `free` or `malloc` on the wrong pointer, correct the error.

If the issue occurs because you use the `free` function to free memory allocated with the `new` operator, replace the `free` function with the `delete` operator.

Example - Invalid Free of Pointer Error

```
#include <stdlib.h>

void Assign_Ones(void)
{
  int p[10];
  for(int i=0;i<10;i++)
     *(p+i)=1;

  free(p);
  /* Defect: p does not point to dynamically allocated memory */
}
```

The pointer `p` is deallocated using the `free` function. However, `p` points to a memory location that was not dynamically allocated.

Correction — Remove Pointer Deallocation

If the number of elements of the array `p` is known at compile time, one possible correction is to remove the deallocation of the pointer `p`.

```
#include <stdlib.h>

void Assign_Ones(void)
 {
  int p[10];
  for(int i=0;i<10;i++)
     *(p+i)=1;
  /* Fix: Remove deallocation of p */
 }
```

Correction — Introduce Pointer Allocation

If the number of elements of the array `p` is not known at compile time, one possible correction is to dynamically allocate memory to the array `p`.

```
#include <stdlib.h>

void Assign_Ones(int num)
{
```

```
  int *p;
  /* Fix: Allocate memory dynamically to p */
  p=(int*) calloc(10,sizeof(int));
  for(int i=0;i<10;i++)
     *(p+i)=1;
  free(p);
}
```

Check Information

Group: Rule 08. Memory Management (MEM)

See Also

External Websites

MEM34-C

Introduced in R2019a

CERT C: Rule MEM35-C

Allocate sufficient memory for an object

Description

Rule Definition

Allocate sufficient memory for an object.

Examples

Pointer access out of bounds

Description

Pointer access out of bounds occurs when a pointer is dereferenced outside its bounds.

When a pointer is assigned an address, a block of memory is associated with the pointer. You cannot access memory beyond that block using the pointer.

Risk

Dereferencing a pointer outside its bounds is undefined behavior. You can read an unpredictable value or try to access a location that is not allowed and encounter a segmentation fault.

Fix

The fix depends on the root cause of the defect. For instance, you dereferenced a pointer inside a loop and one of these situations happened:

- The upper bound of the loop is too large.
- You used pointer arithmetic to advance the pointer with an incorrect value for the pointer increment.

To fix the issue, you have to modify the loop bound or the pointer increment value.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Pointer access out of bounds error

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
   {
    ptr++;
    *ptr=i;
    /* Defect: ptr out of bounds for i=9 */
   }

 return(arr);
}
```

`ptr` is assigned the address `arr` that points to a memory block of size `10*sizeof(int)`. In the `for`-loop, `ptr` is incremented 10 times. In the last iteration of the loop, `ptr` points outside the memory block assigned to it. Therefore, it cannot be dereferenced.

Correction — Check Pointer Stays Within Bounds

One possible correction is to reverse the order of increment and dereference of `ptr`.

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
     {
```

```
      /* Fix: Dereference pointer before increment */
      *ptr=i;
      ptr++;
     }

 return(arr);
}
```

After the last increment, even though `ptr` points outside the memory block assigned to it, it is not dereferenced more.

Memory allocation with tainted size

Description

Memory allocation with tainted size checks memory allocation functions, such as `calloc` or `malloc`, for size arguments from unsecured sources.

Risk

Uncontrolled memory allocation can cause your program to request too much system memory. This consequence can lead to a crash due to an out-of-memory condition, or assigning too many resources.

Fix

Before allocating memory, check the value of your arguments to check that they do not exceed the bounds.

Example - Allocate Memory Using Input Argument

```
#include "stdlib.h"

int* bug_taintedmemoryallocsize(size_t size) {
    int* p = (int*)malloc(size);
    return p;
}
```

In this example, `malloc` allocates `size` amount of memory for the pointer `p`. `size` is an outside variable, so could be any size value. If the size is larger than the amount of memory you have available, your program could crash.

Correction — Check Size of Memory to be Allocated

One possible correction is to check the size of the memory that you want to allocate before performing the `malloc` operation. This example checks to see if the size is positive and less than the maximum size.

```
#include "stdlib.h"

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int* corrected_taintedmemoryallocsize(int size) {
    int* p = NULL;
    if (size>0 && size<SIZE128) {          /* Fix: Check entry range before use */
        p = (int*)malloc((unsigned int)size);
    }
    return p;
}
```

Check Information

Group: Rule 08. Memory Management (MEM)

See Also

External Websites

MEM35-C

Introduced in R2019a

CERT C: Rule MEM36-C

Do not modify the alignment of objects by calling realloc()

Description

Rule Definition

Do not modify the alignment of objects by calling realloc().

Examples

Alignment changed after memory reallocation

Description

Alignment changed after memory reallocation occurs when you use `realloc()` to modify the size of objects with strict memory alignment requirements.

Risk

The pointer returned by `realloc()` can be suitably assigned to objects with less strict alignment requirements. A misaligned memory allocation can lead to buffer underflow or overflow, an illegally dereferenced pointer, or access to arbitrary memory locations. In processors that support misaligned memory, the allocation impacts the performance of the system.

Fix

To reallocate memory:

1. Resize the memory block.
   - In Windows, use `_aligned_realloc()` with the alignment argument used in `_aligned_malloc()` to allocate the original memory block.

- In UNIX/Linux, use the same function with the same alignment argument used to allocate the original memory block.

2. Copy the original content to the new memory block.
3. Free the original memory block.

Note This fix has implementation-defined behavior. The implementation might not support the requested memory alignment and can have additional constraints for the size of the new memory.

Example - Memory Reallocated Without Preserving the Original Alignment

```
#include <stdio.h>
#include <stdlib.h>

#define SIZE1024 1024

void func(void)
{
    size_t resize = SIZE1024;
    size_t alignment = 1 << 12; /* 4096 bytes alignment */
    int *ptr = NULL;
    int *ptr1;

    /* Allocate memory with 4096 bytes alignment */

    if (posix_memalign((void **)&ptr, alignment, sizeof(int)) != 0)
    {
        /* Handle error */
      }

    /*Reallocate memory without using the original alignment.
    ptr1 may not be 4096 bytes aligned. */

    ptr1 = (int *)realloc(ptr, sizeof(int) * resize);

    if (ptr1 == NULL)
    {
        /* Handle error */
    }

    /* Processing using ptr1 */
```

```
    /* Free before exit */
    free(ptr1);
}
```

In this example, the allocated memory is 4096-bytes aligned. `realloc()` then resizes the allocated memory. The new pointer `ptr1` might not be 4096-bytes aligned.

Correction — Specify the Alignment for the Reallocated Memory

When you reallocate the memory, use `posix_memalign()` and pass the alignment argument that you used to allocate the original memory.

```
#include <stdio.h>
#include <stdlib.h>

#define SIZE1024 1024

void func(void)
{
    size_t resize = SIZE1024;
    size_t alignment = 1 << 12; /* 4096 bytes alignment */
    int *ptr = NULL;

    /* Allocate memory with 4096 bytes alignment */
    if (posix_memalign((void **)&ptr, alignment, sizeof(int)) != 0)
    {
        /* Handle error */
    }

    /* Reallocate memory using the original alignment. */
    if (posix_memalign((void **)&ptr, alignment, sizeof(int) * resize) != 0)
    {
        /* Handle error */
        free(ptr);
        ptr = NULL;
    }

    /* Processing using ptr */

    /* Free before exit */
```

```
    free(ptr);
}
```

Check Information

Group: Rule 08. Memory Management (MEM)

See Also

External Websites

MEM36-C

Introduced in R2019a

Rule 09. Input Output (FIO)

CERT C: Rule FIO30-C

Exclude user input from format strings

Description

Rule Definition

Exclude user input from format strings.

Examples

Tainted string format

Description

Tainted string format detects string formatting with `printf`-style functions that contain elements from unsecure sources.

Risk

If you use externally controlled elements to format a string, you can cause buffer overflow or data-representation problems. An attacker can use these string formatting elements to view the contents of a stack using `%x` or write to a stack using `%n`.

Fix

Pass a static string to format string functions. This fix ensures that an external actor cannot control the string.

Another possible fix is to allow only the expected number of arguments. If possible, use functions that do not support the vulnerable `%n` operator in format strings.

Example - Get Elements from User Input

```
#include "stdio.h"
```

```
void taintedstringformat(char* userstr) {
    printf(userstr);
}
```

This example prints the input argument `userstr`. The string is unknown. If it contains elements such as `%`, `printf` can interpret `userstr` as a string format instead of a string, causing your program to crash.

Correction — Print as String

One possible correction is to print `userstr` explicitly as a string so that there is no ambiguity.

```
#include "stdio.h"

void taintedstringformat(char* userstr) {
    printf("%.20s", userstr);
}
```

Check Information

Group: Rule 09. Input Output (FIO)

See Also

External Websites

FIO30-C

Introduced in R2019a

CERT C: Rule FIO32-C

Do not perform operations on devices that are only appropriate for files

Description

Rule Definition

Do not perform operations on devices that are only appropriate for files.

Examples

Inappropriate I/O operation on device files

Description

Inappropriate I/O operation on device files occurs when you do not check whether a file name parameter refers to a device file before you pass it to these functions:

- `fopen()`
- `fopen_s()`
- `freopen()`
- `remove()`
- `rename()`
- `CreateFile()`
- `CreateFileA()`
- `CreateFileW()`
- `_wfopen()`
- `_wfopen_s()`

Device files are files in a file system that provide an interface to device drivers. You can use these files to interact with devices.

Inappropriate I/O operation on device files does not raise a defect when:

- You use `stat` or `lstat`-family functions to check the file name parameter before calling the previously listed functions.
- You use a string comparison function to compare the file name against a list of device file names.

Risk

Operations appropriate only for regular files but performed on device files can result in denial-of-service attacks, other security vulnerabilities, or system failures.

Fix

Before you perform an I/O operation on a file:

- Use `stat()`, `lstat()`, or an equivalent function to check whether the file name parameter refers to a regular file.
- Use a string comparison function to compare the file name against a list of device file names.

Example - Using `fopen()` Without Checking `file_name`

```
#include <stdio.h>
#include <string.h>

#define SIZE1024 1024

FILE* func()
{

    FILE* f;
    const char file_name[SIZE1024] = "./tmp/file";

    if ((f = fopen(file_name, "w")) == NULL) {
        /*handle error */
    };
    /*operate on file */
}
```

In this example, `func()` operates on the file `file_name` without checking whether it is a regular file. If `file_name` is a device file, attempts to access it can result in a system failure.

Correction — Check File with `lstat()` Before Calling `fopen()`

One possible correction is to use `lstat()` and the `S_ISREG` macro to check whether the file is a regular file. This solution contains a `TOCTOU` race condition that can allow an attacker to modify the file after you check it but before the call to fopen(). To prevent this vulnerability, ensure that `file_name` refers to a file in a secure folder.

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include <sys/stat.h>

#define SIZE1024 1024

FILE* func()
{

    FILE* f;
    const char file_name[SIZE1024] = "./tmp/file";
    struct stat orig_st;
    if ((lstat(file_name, &orig_st) != 0) ||
        (!S_ISREG(orig_st.st_mode))) {
        exit(0);
    }
    if ((f = fopen(file_name, "w")) == NULL) {
        /*handle error */
    };
    /*operate on file */
}
```

Check Information

Group: Rule 09. Input Output (FIO)

See Also

External Websites

FIO32-C

Introduced in R2019a

CERT C: Rule FIO34-C

Distinguish between characters read from a file and EOF or WEOF

Description

Rule Definition

Distinguish between characters read from a file and EOF or WEOF.

Examples

Character value absorbed into EOF

Description

Character value absorbed into EOF occurs when you perform a data type conversion that makes a valid character value indistinguishable from `EOF` (End-of-File). Bug Finder flags the defect in one of the following situations:

- *End-of-File*: You perform a data type conversion such as from `int` to `char` that converts a non-EOF character value into `EOF`.

  ```
  char ch = (char)getchar()
  ```

  You then compare the result with EOF.

  ```
  if((int)ch == EOF)
  ```

  The conversion can be explicit or implicit.
- *Wide End-of-File*: You perform a data type conversion that can convert a non-WEOF wide character value into WEOF, and then compare the result with WEOF.

Risk

The data type `char` cannot hold the value `EOF` that indicates the end of a file. Functions such as `getchar` have return type `int` to accommodate `EOF`. If you convert from `int` to

`char`, the values `UCHAR_MAX` (a valid character value) and `EOF` get converted to the same value -1 and become indistinguishable from each other. When you compare the result of this conversion with `EOF`, the comparison can lead to false detection of `EOF`. This rationale also applies to wide character values and `WEOF`.

Fix

Perform the comparison with `EOF` or `WEOF` before conversion.

Example - Return Value of `getchar` Converted to `char`

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

char func(void)
{
    char ch;
    ch = getchar();
    if (EOF == (int)ch) {
        fatal_error();
    }
    return ch;
}
```

In this example, the return value of `getchar` is implicitly converted to `char`. If `getchar` returns `UCHAR_MAX`, it is converted to -1, which is indistinguishable from EOF. When you compare with EOF later, it can lead to a false positive.

Correction — Perform Comparison with EOF Before Conversion

One possible correction is to first perform the comparison with EOF, and then convert from `int` to `char`.

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

char func(void)
{
    int i;
    i = getchar();
    if (EOF == i) {
        fatal_error();
```

```
    }
    else {
        return (char)i;
    }
}
```

Check Information

Group: Rule 09. Input Output (FIO)

See Also

External Websites

FIO34-C

Introduced in R2019a

CERT C: Rule FIO37-C

Do not assume that fgets() or fgetws() returns a nonempty string when successful

Description

Rule Definition

Do not assume that fgets() or fgetws() returns a nonempty string when successful.

Examples

Use of indeterminate string

Description

Use of indeterminate string occurs when you do not check the validity of the buffer returned from `fgets`-family functions. The checker raises a defect when such a buffer is used as:

- An argument in standard functions that print or manipulate strings or wide strings.
- A return value.
- An argument in external functions with parameter type `const char *` or `const wchar_t *`.

Risk

If an `fgets`-family function fails, the content of its output buffer is indeterminate. Use of such a buffer has undefined behavior and can result in a program that stops working or other security vulnerabilities.

Fix

Reset the output buffer of an `fgets`-family function to a known string value when the function fails.

Example - Output of `fgets()` Passed to External Function

```
#include <stdio.h>
#include <wchar.h>
#include <string.h>
#include <stdlib.h>

#define SIZE20 20

extern void display_text(const char *txt);

void func(void) {
    char buf[SIZE20];

    /* Check fgets() error */
    if (fgets (buf, sizeof (buf), stdin) == NULL)
    {
        /* 'buf' may contain an indeterminate string.  */
        ;
    }
    /* 'buf passed to external function */
    display_text(buf);
}
```

In this example, the output `buf` is passed to the external function `display_text()`, but its value is not reset if `fgets()` fails.

Correction — Reset `fgets()` Output on Failure

If `fgets()` fails, reset `buf` to a known value before you pass it to an external function.

```
#include <stdio.h>
#include <wchar.h>
#include <string.h>
#include <stdlib.h>

#define SIZE20 20

extern void display_text(const char *txt);

void func1(void) {
    char buf[SIZE20];
    /* Check fgets() error */
```

```
    if (fgets (buf, sizeof (buf), stdin) == NULL)
    {
        /* value of 'buf' reset after fgets() failure. */
        buf[0] = '\0';
    }
    /* 'buf' passed to external function */
    display_text(buf);
}
```

Check Information

Group: Rule 09. Input Output (FIO)

See Also

External Websites

FIO37-C

Introduced in R2019a

CERT C: Rule FIO38-C

Do not copy a FILE object

Description

Rule Definition

Do not copy a FILE object.

Examples

Misuse of a FILE object

Description

Misuse of a FILE object occurs when:

- You dereference a pointer to a FILE object, including indirect dereference by using `memcmp()`.
- You modify an entire FILE object or one of its components through its pointer.
- You take the address of FILE object that was not returned from a call to an `fopen`-family function. No defect is raised if a macro defines the pointer as the address of a built-in FILE object, such as `#define ptr (&__stdout)`.

Risk

In some implementations, the address of the pointer to a FILE object used to control a stream is significant. A pointer to a copy of a FILE object is interpreted differently than a pointer to the original object, and can potentially result in operations on the wrong stream. Therefore, the use of a copy of a FILE object can cause the software to stop responding, which an attacker might exploit in denial-of-service attacks.

Fix

Do not make a copy of a FILE object. Do not use the address of a FILE object that was not returned from a successful call to an `fopen`-family function.

Example - Copy of FILE Object Used in `fputs()`

```
#include <stdio.h>
#include <unistd.h>
#include <stdlib.h>
#include <string.h>
#include <strings.h>

void fatal_error(void);

int func(void)
{
    /*'stdout' dereferenced and contents
        copied to 'my_stdout'. */
    FILE my_stdout = *stdout;

    /* Address of 'my_stdout' may not point to correct stream. */
    if (fputs("Hello, World!\n", &my_stdout) == EOF)
    {
        /* Handler error */
        fatal_error();
    }
    return 0;
}
```

In this example, FILE object `stdout` is dereferenced and its contents are copied to `my_stdout`. The contents of `stdout` might not be significant. `fputs()` is then called with the address of `my_stdout` as an argument. Because no call to `fopen()` or a similar function was made, the address of `my_stdout` might not point to the correct stream.

Correction — Copy the FILE Object Pointer

Declare `my_stdout` to point to the same address as `stdout` to ensure that you write to the correct stream when you call `fputs()`.

```
#include <stdio.h>
#include <unistd.h>
```

```
#include <stdlib.h>
#include <string.h>
#include <strings.h>

void fatal_error(void);

int func(void)
{
    /* 'my_stdout' and 'stdout' point to the same object. */
    FILE *my_stdout = stdout;
    if (fputs("Hello, World!\n", my_stdout) == EOF)
    {
        /* Handler error */
        fatal_error();
    }
    return 0;
}
```

Check Information

Group: Rule 09. Input Output (FIO)

See Also

External Websites

FIO38-C

Introduced in R2019a

CERT C: Rule FIO39-C

Do not alternately input and output from a stream without an intervening flush or positioning call

Description

Rule Definition

Do not alternately input and output from a stream without an intervening flush or positioning call.

Examples

Alternating input and output from a stream without flush or positioning call

Description

Alternating input and output from a stream without flush or positioning call occurs when:

- You do not perform a flush or function positioning call between an output operation and a following input operation on a file stream in update mode.
- You do not perform a function positioning call between an input operation and a following output operation on a file stream in update mode.

Risk

Alternating input and output operations on a stream without an intervening flush or positioning call is undefined behavior.

Fix

Call `fflush()` or a file positioning function such as `fseek()` or `fsetpos()` between output and input operations on an update stream.

Call a file positioning function between input and output operations on an update stream.

Example - Read After Write Without Intervening Flush

```
#include <stdio.h>
#define SIZE20 20

void initialize_data(char* data, size_t s) {};
const char *temp_filename = "/tmp/demo.txt";

void func()
{
    char data[SIZE20];
    char append_data[SIZE20];
    FILE *file;

    file = fopen(temp_filename, "a+");
    if (file == NULL)
      {
        /* Handle error. */;
      }

    initialize_data(append_data, SIZE20);

    if (fwrite(append_data, 1, SIZE20, file) != SIZE20)
      {
        (void)fclose(file);
        /* Handle error. */;
      }
    /* Read operation after write without
    intervening flush. */
    if (fread(data, 1, SIZE20, file) < SIZE20)
      {
          (void)fclose(file);
          /* Handle error. */;
      }

    if (fclose(file) == EOF)
      {
        /* Handle error. */;
      }
}
```

In this example, the file `demo.txt` is opened for reading and appending. After the call to `fwrite()`, a call to `fread()` without an intervening flush operation is undefined behavior.

Correction — Call `fflush()` Before the Read Operation

After writing data to the file, before calling `fread()`, perform a flush call.

```
#include <stdio.h>
#define SIZE20 20

void initialize_data(char* data, size_t s) {};
const char *temp_filename = "/tmp/demo.txt";


void func()
{
    char data[SIZE20];
    char append_data[SIZE20];
    FILE *file;

    file = fopen(temp_filename, "a+");
    if (file == NULL)
      {
        /* Handle error. */;
      }

    initialize_data(append_data, SIZE20);

    if (fwrite(append_data, 1, SIZE20, file) != SIZE20)
      {
        (void)fclose(file);
        /* Handle error. */;
      }
    /* Buffer flush after write and before read */
    if (fflush(file) != 0)
      {
        (void)fclose(file);
        /* Handle error. */;
      }
    if (fread(data, 1, SIZE20, file) < SIZE20)
      {
        (void)fclose(file);
        /* Handle error. */;
```

```
      }

    if (fclose(file) == EOF)
      {
        /* Handle error. */;
      }
}
```

Check Information

Group: Rule 09. Input Output (FIO)

See Also

External Websites

FIO39-C

Introduced in R2019a

CERT C: Rule FIO40-C

Reset strings on fgets() or fgetws() failure

Description

Rule Definition

Reset strings on fgets() or fgetws() failure.

Examples

Use of indeterminate string

Description

Use of indeterminate string occurs when you do not check the validity of the buffer returned from `fgets`-family functions. The checker raises a defect when such a buffer is used as:

- An argument in standard functions that print or manipulate strings or wide strings.
- A return value.
- An argument in external functions with parameter type `const char *` or `const wchar_t *`.

Risk

If an `fgets`-family function fails, the content of its output buffer is indeterminate. Use of such a buffer has undefined behavior and can result in a program that stops working or other security vulnerabilities.

Fix

Reset the output buffer of an `fgets`-family function to a known string value when the function fails.

Example - Output of `fgets()` Passed to External Function

```
#include <stdio.h>
#include <wchar.h>
#include <string.h>
#include <stdlib.h>

#define SIZE20 20

extern void display_text(const char *txt);

void func(void) {
    char buf[SIZE20];

    /* Check fgets() error */
    if (fgets (buf, sizeof (buf), stdin) == NULL)
    {
        /* 'buf' may contain an indeterminate string.  */
        ;
    }
    /* 'buf passed to external function */
    display_text(buf);
}
```

In this example, the output `buf` is passed to the external function `display_text()`, but its value is not reset if `fgets()` fails.

Correction — Reset `fgets()` Output on Failure

If `fgets()` fails, reset `buf` to a known value before you pass it to an external function.

```
#include <stdio.h>
#include <wchar.h>
#include <string.h>
#include <stdlib.h>

#define SIZE20 20

extern void display_text(const char *txt);

void func1(void) {
    char buf[SIZE20];
    /* Check fgets() error */
```

```
    if (fgets (buf, sizeof (buf), stdin) == NULL)
    {
        /* value of 'buf' reset after fgets() failure. */
        buf[0] = '\0';
    }
    /* 'buf' passed to external function */
    display_text(buf);
}
```

Check Information

Group: Rule 09. Input Output (FIO)

See Also

External Websites

FIO40-C

Introduced in R2019a

CERT C: Rule FIO41-C

Do not call getc(), putc(), getwc(), or putwc() with a stream argument that has side effects

Description

Rule Definition

Do not call getc(), putc(), getwc(), or putwc() with a stream argument that has side effects.

Examples

Stream argument with possibly unintended side effects

Description

Stream argument with possibly unintended side effects occurs when you call `getc()`, `putc()`, `getwc()`, or `putwc()` with a stream argument that has side effects.

Stream argument with possibly unintended side effects considers the following as stream side effects:

- Any assignment of a variable of a stream, such as `FILE *`, or any assignment of a variable of a deeper stream type, such as an array of `FILE *`.
- Any call to a function that manipulates a stream or a deeper stream type.

The number of defects raised corresponds to the number of side effects detected. When a stream argument is evaluated multiple times in a function implemented as a macro, a defect is raised for each evaluation that has a side effect.

A defect is also raised on functions that are not implemented as macros but that can be implemented as macros on another operating system.

Risk

If the function is implemented as an unsafe macro, the stream argument can be evaluated more than once, and the stream side effect happens multiple times. For instance, a stream argument calling `fopen()` might open the same file multiple times, which is unspecified behavior.

Fix

To ensure that the side effect of a stream happens only once, use a separate statement for the stream argument.

Example - Stream Argument of `getc()` Has Side Effect `fopen()`

```
#include <stddef.h>
#include <stdio.h>
#include <stdlib.h>

#define fatal_error() abort()

const char* myfile = "my_file.log";

void func(void)
{
    int c;
    FILE* fptr;
    /* getc() has stream argument fptr with
    * 2 side effects: call to fopen(), and assignment
    * of fptr
    */
    c = getc(fptr = fopen(myfile, "r"));
    if (c == EOF) {
        /* Handle error */
        (void)fclose(fptr);
        fatal_error();
    }
    if (fclose(fptr) == EOF) {
        /* Handle error */
        fatal_error();
    }
}

void main(void)
{
```

```
    func();

}
```

In this example, `getc()` is called with stream argument `fptr`. The stream argument has two side effects: the call to `fopen()` and the assignment of `fptr`. If `getc()` is implemented as an unsafe macro, the side effects happen multiple times.

Correction — Use Separate Statement for `fopen()`

One possible correction is to use a separate statement for `fopen()`. The call to `fopen()` and the assignment of `fptr` happen in this statement so there are no side effects when you pass `fptr` to `getc()`.

```
#include <stddef.h>
#include <stdio.h>
#include <stdlib.h>

#define fatal_error() abort()


const char* myfile = "my_file.log";

void func(void)
{
    int c;
    FILE* fptr;

    /* Separate statement for fopen()
    * before call to getc()
    */
    fptr = fopen(myfile, "r");
    if (fptr == NULL) {
        /* Handle error */
        fatal_error();
    }
    c = getc(fptr);
    if (c == EOF) {
        /* Handle error */
        (void)fclose(fptr);
        fatal_error();
    }
    if (fclose(fptr) == EOF) {
        /* Handle error */
```

```
        fatal_error();
    }
}

void main(void)
{
    func();

}
```

Check Information

Group: Rule 09. Input Output (FIO)

See Also

External Websites

FIO41-C

Introduced in R2019a

CERT C: Rule FIO42-C

Close files when they are no longer needed

Description

Rule Definition

Close files when they are no longer needed.

Examples

Resource leak

Description

Resource leak occurs when you open a file stream by using a `FILE` pointer but do not close it before:

- The end of the pointer's scope.
- Assigning the pointer to another stream.

Risk

If you do not release file handles explicitly as soon as possible, a failure can occur due to exhaustion of resources.

Fix

Close a `FILE` pointer before the end of its scope, or before you assign the pointer to another stream.

Example - `FILE` Pointer Not Released Before End of Scope

```
#include <stdio.h>
```

```
void func1( void ) {
    FILE *fp1;
    fp1 = fopen ( "data1.txt", "w" );
    fprintf ( fp1, "*" );

    fp1 = fopen ( "data2.txt", "w" );
    fprintf ( fp1, "!" );
    fclose ( fp1 );
}
```

In this example, the file pointer `fp1` is pointing to a file `data1.txt`. Before `fp1` is explicitly dissociated from the file stream of `data1.txt`, it is used to access another file `data2.txt`.

Correction — Release `FILE` Pointer

One possible correction is to explicitly dissociate `fp1` from the file stream of `data1.txt`.

```
#include <stdio.h>

void func1( void ) {
    FILE *fp1;
    fp1 = fopen ( "data1.txt", "w" );
    fprintf ( fp1, "*" );
    fclose(fp1);

    fp1 = fopen ( "data2.txt", "w" );
    fprintf ( fp1, "!" );
    fclose ( fp1 );
}
```

Check Information

Group: Rule 09. Input Output (FIO)

See Also

External Websites

FIO42-C

Introduced in R2019a

CERT C: Rule FIO44-C

Only use values for fsetpos() that are returned from fgetpos()

Description

Rule Definition

Only use values for fsetpos() that are returned from fgetpos().

Examples

Invalid file position

Description

Invalid file position occurs when the file position argument of `fsetpos()` uses a value that is not obtained from `fgetpos()`.

Risk

The function `fgetpos(FILE *stream, fpos_t *pos)` gets the current file position of the stream. When you use any other value as the file position argument of `fsetpos(FILE *stream, const fpos_t *pos)`, you might access an unintended location in the stream.

Fix

Use the value returned from a successful call to `fgetpos()` as the file position argument of `fsetpos()`.

Example - `memset()` Sets File Position Argument

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
```

```
FILE *func(FILE *file)
{
    fpos_t offset;
    if (file == NULL)
    {
        /* Handle error */
    }
    /* Store initial position in variable 'offset' */
    (void)memset(&offset, 0, sizeof(offset));

    /* Read data from file */

    /* Return to the initial position. offset was not
    returned from a call to fgetpos()    */
    if (fsetpos(file, &offset) != 0)
    {
        /* Handle error */
    }
    return file;
}
```

In this example, `fsetpos()` uses `offset` as its file position argument. However, the value of `offset` is set by `memset()`. The preceding code might access the wrong location in the stream.

Correction — Use a File Position Returned From `fgetpos()`

Call `fgetpos()`, and if it returns successfully, use the position argument in your call to `fsetpos()`.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

FILE *func(FILE *file)
{
    fpos_t offset;
    if (file == NULL)
    {
        /* Handle error */
```

```
    }
    /* Store initial position in variable 'offset'
    using fgetpos() */
    if (fgetpos(file, &offset) != 0)
    {
        /* Handle error */
    }

    /* Read data from file */

    /* Back to the initial position */
    if (fsetpos(file, &offset) != 0)
    {
        /* Handle error */
    }
    return file;
}
```

Check Information

Group: Rule 09. Input Output (FIO)

See Also

External Websites

FIO44-C

Introduced in R2019a

CERT C: Rule FIO45-C

Avoid TOCTOU race conditions while accessing files

Description

Rule Definition

Avoid TOCTOU race conditions while accessing files.

Examples

File access between time of check and use (TOCTOU)

Description

File access between time of check and use (TOCTOU) detects race condition issues between checking the existence of a file or folder, and using a file or folder.

Risk

An attacker can access and manipulate your file between your check for the file and your use of a file. Symbolic links are particularly risky because an attacker can change where your symbolic link points.

Fix

Before using a file, do not check its status. Instead, use the file and check the results afterward.

Example - Check File Before Using

```
#include <stdio.h>
#include <fcntl.h>
#include <unistd.h>
```

```
extern void print_tofile(FILE* f);

void toctou(char * log_path) {
    if (access(log_path, W_OK)==0) {
        FILE* f = fopen(log_path, "w");
        if (f) {
            print_tofile(f);
            fclose(f);
        }
    }
}
```

In this example, before opening and using the file, the function checks if the file exists. However, an attacker can change the file between the first and second lines of the function.

Correction — Open Then Check

One possible correction is to open the file, and then check the existence and contents afterward.

```
#include <stdio.h>
#include <fcntl.h>
#include <unistd.h>

extern void print_tofile(FILE* f);

void toctou(char * log_path) {
    int fd = open(log_path, O_WRONLY);
    if (fd!=-1) {
        FILE *f = fdopen(fd, "w");
        if (f) {
            print_tofile(f);
            fclose(f);
        }
    }
}
```

Check Information

Group: Rule 09. Input Output (FIO)

See Also

External Websites

FIO45-C

Introduced in R2019a

CERT C: Rule FIO46-C

Do not access a closed file

Description

Rule Definition

Do not access a closed file.

Examples

Use of previously closed resource

Description

Use of previously closed resource occurs when a function operates on a stream that you closed earlier in your code.

Risk

The standard states that the value of a `FILE*` pointer is indeterminate after you close the stream associated with it. Operations using the `FILE*` pointer can produce unintended results.

Fix

One possible fix is to close the stream only at the end of operations. Another fix is to reopen the stream before using it again.

Example - Use of `FILE*` Pointer After Closing Stream

```
#include <stdio.h>

void func(void) {
    FILE *fp;
```

```
    void *ptr;

    fp = fopen("tmp","w");
    if(fp != NULL) {
        fclose(fp);
        fprintf(fp,"text");
    }
}
```

In this example, `fclose` closes the stream associated with `fp`. When you use `fprintf` on `fp` after `fclose`, the **Use of previously closed resource** defect appears.

Correction — Close Stream After All Operations

One possible correction is to reverse the order of the `fprintf` and `fclose` operations.

```
#include <stdio.h>

void func(void) {
    FILE *fp;
    void *ptr;

    fp = fopen("tmp","w");
    if(fp != NULL) {
        fprintf(fp,"text");
        fclose(fp);
    }
}
```

Check Information

Group: Rule 09. Input Output (FIO)

See Also

External Websites

FIO46-C

Introduced in R2019a

CERT C: Rule FIO47-C

Use valid format strings

Description

Rule Definition

Use valid format strings.

Examples

Format string specifiers and arguments mismatch

Description

Format string specifiers and arguments mismatch occurs when the format specifiers in the formatted output functions such as `printf` do not match their corresponding arguments. For example, an argument of type `unsigned long` must have a format specification of `%lu`.

Risk

Mismatch between format specifiers and the corresponding arguments result in undefined behavior.

Fix

Make sure that the format specifiers match the corresponding arguments. For instance, in this example, the `%d` specifier does not match the string argument `message` and the `%s` specifier does not match the integer argument `err_number`.

```
const char *message = "License not available";
int err_number = ;-4
printf("Error: %d (error type %s)\n", message, err_number);
```

Switching the two format specifiers fixes the issue. See the specifications for the printf function for more information about format specifiers.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Printing a Float

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;

    printf("%d\n", fst);
}
```

In the `printf` statement, the format specifier, `%d`, does not match the data type of `fst`.

Correction — Use an Unsigned Long Format Specifier

One possible correction is to use the `%lu` format specifier. This specifier matches the `unsigned` integer type and `long` size of `fst`.

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;

    printf("%lu\n", fst);
}
```

Correction — Use an Integer Argument

One possible correction is to change the argument to match the format specifier. Convert `fst` to an integer to match the format specifier and print the value `1`.

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;
```

```
    printf("%d\n", (int)fst);
}
```

Check Information

Group: Rule 09. Input Output (FIO)

See Also

External Websites

FIO47-C

Introduced in R2019a

Rule 10. Environment (ENV)

CERT C: Rule ENV30-C

Do not modify the object referenced by the return value of certain functions

Description

Rule Definition

Do not modify the object referenced by the return value of certain functions.

Examples

Modification of internal buffer returned from nonreentrant standard function

Description

Modification of internal buffer returned from nonreentrant standard function occurs when the following happens:

- A nonreentrant standard function returns a pointer.
- You attempt to write to the memory location that the pointer points to.

Nonreentrant standard functions that return a non `const`-qualified pointer to an internal buffer include `getenv`, `getlogin`, `crypt`, `setlocale`, `localeconv`, `strerror` and others.

Risk

Modifying the internal buffer that a nonreentrant standard function returns can cause the following issues:

- It is possible that the modification does not succeed or alters other internal data.

  For instance, `getenv` returns a pointer to an environment variable value. If you modify this value, you alter the environment of the process and corrupt other internal data.

- Even if the modification succeeds, it is possible that a subsequent call to the same standard function does not return your modified value.

  For instance, you modify the environment variable value that `getenv` returns. If another process, thread, or signal handler calls `setenv`, the modified value is overwritten. Therefore, a subsequent call to `getenv` does not return your modified value.

Fix

Avoid modifying the internal buffer using the pointer returned from the function.

Example - Modification of `getenv` Return Value

```
#include <stdlib.h>
#include <string.h>

void printstr(const char*);

void func() {
    char* env = getenv("LANGUAGE");
    if (env != NULL) {
        strncpy(env, "C", 1);
        printstr(env);
    }
}
```

In this example, the first argument of `strncpy` is the return value from a nonreentrant standard function `getenv`. The behavior can be undefined because `strncpy` modifies this argument.

Correction - Copy Return Value of `getenv` and Modify Copy

One possible solution is to copy the return value of `getenv` and pass the copy to the `strncpy` function.

```
#include <stdlib.h>
#include <string.h>
enum {
    SIZE20 = 20
};

void printstr(const char*);
```

```
void func() {
    char* env = getenv("LANGUAGE");
    if (env != NULL) {
        char env_cp[SIZE20];
        strncpy(env_cp, env, SIZE20);
        strncpy(env_cp, "C", 1);
        printstr(env_cp);
    }
}
```

Check Information

Group: Rule 10. Environment (ENV)

See Also

External Websites

ENV30-C

Introduced in R2019a

CERT C: Rule ENV31-C

Do not rely on an environment pointer following an operation that may invalidate it

Description

Rule Definition

Do not rely on an environment pointer following an operation that may invalidate it.

Examples

Environment pointer invalidated by previous operation

Description

Environment pointer invalidated by previous operation occurs when you use the third argument of *main()* in a hosted environment to access the environment after an operation modifies the environment. In a hosted environment, many C implementations support the nonstandard syntax:

```
main (int argc, char *argv[], char *envp[])
```

A call to a `setenv` or `putenv` family function modifies the environment pointed to by `*envp`.

Risk

When you modify the environment through a call to a `setenv` or `putenv` family function, the environment memory can potentially be reallocated. The hosted environment pointer is not updated and might point to an incorrect location. A call to this pointer can return unexpected results or cause an abnormal program termination.

Fix

Do not use the hosted environment pointer. Instead, use global external variable `environ` in Linux, `_environ` or `_wenviron` in Windows, or their equivalent. When you modify the environment, these variables are updated.

Example - Access Environment Through Pointer envp

```
#include <stdio.h>
#include <stdlib.h>

extern int check_arguments(int argc, char **argv, char **envp);
extern void use_envp(char **envp);

/* envp is from main function */
int func(char **envp)
{
    /* Call to setenv may cause environment
     *memory to be reallocated
     */
    if (setenv(("MY_NEW_VAR"),("new_value"),1) != 0)
    {
        /* Handle error */
        return -1;
    }
    /* envp not updated after call to setenv, and may
     *point to incorrect location.
     **/
    if (envp != ((void *)0)) {
        use_envp(envp);
/* No defect on second access to
*envp because defect already raised */
    }
    return 0;
}

void  main(int argc, char **argv, char **envp)
{
    if (check_arguments(argc, argv, envp))
    {
        (void)func(envp);
    }
}
```

In this example, `envp` is accessed inside `func()` after a call to `setenv` that can reallocate the environment memory. `envp` can point to an incorrect location because it is not updated after `setenv` modifies the environment. No defect is raised when `use_envp()` is called because the defect is already raised on the previous line of code.

Correction — Use Global External Variable `environ`

One possible correction is to access the environment by using a variable that is always updated after a call to `setenv`. For instance, in the following code, the pointer `envp` is still available from `main()`, but the environment is accessed in `func()` through the global external variable `environ`.

```
#include <stdio.h>
#include <stdlib.h>
extern char **environ;

extern int check_arguments(int argc, char **argv, char **envp);
extern void use_envp(char **envp);

int func(void)
{
    if (setenv(("MY_NEW_VAR"), ("new_value"),1) != 0) {
        /* Handle error */
        return -1;
    }
  /* Use global external variable environ
   *which is always updated after a call to setenv */

    if (environ != NULL) {
        use_envp(environ);
    }
    return 0;
}

void  main(int argc, char **argv, char **envp)
{
    if (check_arguments(argc, argv, envp))
    {
        (void)func();
    }
}
```

Check Information

Group: Rule 10. Environment (ENV)

See Also

External Websites

ENV31-C

Introduced in R2019a

CERT C: Rule ENV32-C

All exit handlers must return normally

Description

Rule Definition

All exit handlers must return normally.

Examples

Abnormal termination of exit handler

Description

Abnormal termination of exit handler looks for registered exit handlers. Exit handlers are registered with specific functions such as `atexit`, (WinAPI) `_onexit`, or `at_quick_exit()`. If the exit handler calls a function that interrupts the program's expected termination sequence, Polyspace raises a defect. Some functions that can cause abnormal exits are `exit`, `abort`, `longjmp`, or (WinAPI) `_onexit`.

Risk

If your exit handler terminates your program, you can have undefined behavior. Abnormal program termination means other exit handlers are not invoked. These additional exit handlers may do additional clean up or other required termination steps.

Fix

In inside exit handlers, remove calls to functions that prevent the exit handler from terminating normally.

Example - Exit Handler With Call to `exit`

```
#include <stdlib.h>
```

```
volatile int some_condition = 1;
void demo_exit1(void)
{
    /* ... Cleanup code ... */
    return;
}
void exitabnormalhandler(void)
{
    if (some_condition)
    {
        /* Clean up */
        exit(0);
    }
    return;
}

int demo_install_exitabnormalhandler(void)
{

    if (atexit(demo_exit1) != 0) /* demo_exit1() performs additional cleanup */
    {
        /* Handle error */
    }
    if (atexit(exitabnormalhandler) != 0)
    {
        /* Handle error */
    }
    /* ... Program code ... */
    return 0;
}
```

In this example, `demo_install_exitabnormalhandler` registers two exit handlers, `demo_exit1` and `exitabnormalhandler`. Exit handlers are invoked in the reverse order of which they are registered. When the program ends, `exitabnormalhandler` runs, then `demo_exit1`. However, `exitabnormalhandler` calls `exit` interrupting the program exit process. Having this `exit` inside an exit handler causes undefined behavior because the program is not finished cleaning up safely.

Correction — Remove `exit` from Exit Handler

One possible correction is to let your exit handlers terminate normally. For this example, `exit` is removed from `exitabnormalhandler`, allowing the exit termination process to complete as expected.

```
#include <stdlib.h>

volatile int some_condition = 1;
void demo_exit1(void)
{
    /* ... Cleanup code ... */
    return;
}
void exitabnormalhandler(void)
{
    if (some_condition)
    {
        /* Clean up */
        /* Return normally */
    }
    return;
}

int demo_install_exitabnormalhandler(void)
{

    if (atexit(demo_exit1) != 0) /* demo_exit1() continues clean up */
    {
        /* Handle error */
    }
    if (atexit(exitabnormalhandler) != 0)
    {
        /* Handle error */
    }
    /* ... Program code ... */
    return 0;
}
```

Check Information

Group: Rule 10. Environment (ENV)

See Also

External Websites

ENV32-C

Introduced in R2019a

CERT C: Rule ENV33-C

Do not call system()

Description

Rule Definition

Do not call system().

Examples

Unsafe call to a system function

Description

Unsafe call to a system function occurs when you use a function that invokes an implementation-defined command processor. These functions include:

- The C standard `system()` function.
- The POSIX `popen()` function.
- The Windows `_popen()` and `_wpopen()` functions.

Risk

If the argument of a function that invokes a command processor is not sanitized, it can cause exploitable vulnerabilities. An attacker can execute arbitrary commands or read and modify data anywhere on the system.

Fix

Do not use a `system`-family function to invoke a command processor. Instead, use safer functions such as POSIX `execve()` and WinAPI `CreateProcess()`.

Example - `system()` Called

```
# include <string.h>
# include <stdlib.h>
# include <stdio.h>
# include <unistd.h>

enum {
SIZE512=512,
SIZE3=3};

void func(char *arg)
{
    char buf[SIZE512];
    int retval=sprintf(buf, "/usr/bin/any_cmd %s", arg);

    if (retval<=0 || retval>SIZE512){
        /* Handle error */
        abort();
    }
    /* Use of system() to pass any_cmd with
    unsanitized argument to command processor */

    if (system(buf) == -1) {
    /* Handle error */
  }
}
```

In this example, `system()` passes its argument to the host environment for the command processor to execute. This code is vulnerable to an attack by command-injection.

Correction — Sanitize Argument and Use `execve()`

In the following code, the argument of `any_cmd` is sanitized, and then passed to `execve()` for execution. `exec`-family functions are not vulnerable to command-injection attacks.

```
# include <string.h>
# include <stdlib.h>
# include <stdio.h>
# include <unistd.h>

enum {
SIZE512=512,
```

```
SIZE3=3};


void func(char *arg)
{
  char *const args[SIZE3] = {"any_cmd", arg, NULL};
  char  *const env[] = {NULL};

  /* Sanitize argument */

  /* Use execve() to execute any_cmd. */

  if (execve("/usr/bin/time", args, env) == -1) {
    /* Handle error */
  }
}
```

Check Information

Group: Rule 10. Environment (ENV)

See Also

External Websites

ENV33-C

Introduced in R2019a

CERT C: Rule ENV34-C

Do not store pointers returned by certain functions

Description

Rule Definition

Do not store pointers returned by certain functions.

Examples

Misuse of return value from nonreentrant standard function

Description

Misuse of return value from nonreentrant standard function occurs when these events happen in this sequence:

1. You point to the buffer returned from a nonreentrant standard function such as `getenv` or `setlocale`.

   ```
   user = getenv("USER");
   ```

2. You call that nonreentrant standard function again.

   ```
   user2 = getenv("USER2");
   ```

3. You use or dereference the pointer from the first step expecting the buffer to remain unmodified since that step. In the meantime, the call in the second step has modified the buffer.

   For instance:

   ```
   var=*user;
   ```

In some cases, the defect might appear even if you do not call the `getenv` function a second time but simply return the pointer. For instance:

```
char* func() {
     user=getenv("USER");
     .
     .
     return user;
}
```

For information on which functions are covered by this defect, see documentation on nonreentrant standard functions.

Risk

The C Standard allows nonreentrant functions such as `getenv` to return a pointer to a *static* buffer. Because the buffer is static, a second call to `getenv` modifies the buffer. If you continue to use the pointer returned from the first call past the second call, you can see unexpected results. The buffer that it points to no longer has values from the first call.

The defect appears even if you do not call `getenv` a second time but simply return the pointer. The reason is that someone calling your function might use the returned pointer *after* a second call to `getenv`. By returning the pointer from your call to `getenv`, you make your function unsafe to use.

The same rationale is true for other nonreentrant functions covered by this defect.

Fix

After the first call to `getenv`, make a copy of the buffer that the returned pointer points to. After the second call to `getenv`, use this copy. Even if the second call modifies the buffer, your copy is untouched.

Example - Return from `getenv` Used After Second Call to `getenv`

```
#include <stdlib.h>
#include <string.h>

int func()
{
    int result = 0;

    char *home = getenv("HOME");   /* First call */
    if (home != NULL) {
        char *user = NULL;
        char *user_name_from_home = strrchr(home, '/');
```

```
        if (user_name_from_home != NULL) {
            user = getenv("USER");   /* Second call */
            if ((user != NULL) &&
                (strcmp(user, user_name_from_home) == 0))
            {
                result = 1;
            }
        }
    }
    return result;
}
```

In this example, the pointer `user_name_from_home` is derived from the pointer `home`. `home` points to the buffer returned from the first call to `getenv`. Therefore, `user_name_from_home` points to a location in the same buffer.

After the second call to `getenv`, the buffer is modified. If you continue to use `user_name_from_home`, you can get unexpected results.

Correction — Make Copy of Buffer Before Second Call

If you want to access the buffer from the first call to `getenv` past the second call, make a copy of the buffer after the first call. One possible correction is to use the `strdup` function to make the copy.

```
#include <stdlib.h>
#include <string.h>

int func()
{
    int result = 0;

    char *home = getenv("HOME");
    if (home != NULL) {
        char *user = NULL;
        char *user_name_from_home = strrchr(home, '/');
        if (user_name_from_home != NULL) {
            /* Make copy before second call */
            char *saved_user_name_from_home = strdup(user_name_from_home);
            if (saved_user_name_from_home != NULL) {
                user = getenv("USER");
                if ((user != NULL) &&
                    (strcmp(user, saved_user_name_from_home) == 0))
                {
```

```
                    result = 1;
                }
                free(saved_user_name_from_home);
            }
        }
    }
    return result;
}
```

Check Information

Group: Rule 10. Environment (ENV)

See Also

External Websites

ENV34-C

Introduced in R2019a

Rule 11. Signals (SIG)

CERT C: Rule SIG30-C

Call only asynchronous-safe functions within signal handlers

Description

Rule Definition

Call only asynchronous-safe functions within signal handlers.

Examples

Function called from signal handler not asynchronous-safe

Description

Function called from signal handler not asynchronous-safe occurs when a signal handler calls a function that is not asynchronous-safe according to the POSIX standard. An asynchronous-safe function can be interrupted at any point in its execution, then called again without causing an inconsistent state. It can also correctly handle global data that might be in an inconsistent state.

If a signal handler calls another function that calls an asynchronous-unsafe function, the defect appears on the function call in the signal handler. The defect traceback shows the full path from the signal handler to the asynchronous-unsafe function.

Risk

When a signal handler is invoked, the execution of the program is interrupted. After the handler is finished, program execution resumes at the point of interruption. If a function is executing at the time of the interruption, calling it from within the signal handler is undefined behavior, unless it is asynchronous-safe.

Fix

The POSIX standard defines these functions as asynchronous-safe. You can call these functions from a signal handler.

_exit()	getpgrp()	setsockopt()
_Exit()	getpid()	setuid()
abort()	getppid()	shutdown()
accept()	getsockname()	sigaction()
access()	getsockopt()	sigaddset()
aio_error()	getuid()	sigdelset()
aio_return()	kill()	sigemptyset()
aio_suspend()	link()	sigfillset()
alarm()	linkat()	sigismember()
bind()	listen()	signal()
cfgetispeed()	lseek()	sigpause()
cfgetospeed()	lstat()	sigpending()
cfsetispeed()	mkdir()	sigprocmask()
cfsetospeed()	mkdirat()	sigqueue()
chdir()	mkfifo()	sigset()
chmod()	mkfifoat()	sigsuspend()
chown()	mknod()	sleep()
clock_gettime()	mknodat()	sockatmark()
close()	open()	socket()
connect()	openat()	socketpair()
creat()	pathconf()	stat()
dup()	pause()	symlink()
dup2()	pipe()	symlinkat()
execl()	poll()	sysconf()
execle()	posix_trace_event()	tcdrain()

execv()	pselect()	tcflow()
execve()	pthread_kill()	tcflush()
faccessat()	pthread_self()	tcgetattr()
fchdir()	pthread_sigmask()	tcgetpgrp()
fchmod()	quick_exit()	tcsendbreak()
fchmodat()	raise()	tcsetattr()
fchown()	read()	tcsetpgrp()
fchownat()	readlink()	time()
fcntl()	readlinkat()	timer_getoverrun()
fdatasync()	recv()	timer_gettime()
fexecve()	recvfrom()	timer_settime()
fork()	recvmsg()	times()
fpathconf()	rename()	umask()
fstat()	renameat()	uname()
fstatat()	rmdir()	unlink()
fsync()	select()	unlinkat()
ftruncate()	sem_post()	utime()
futimens()	send()	utimensat()
getegid()	sendmsg()	utimes()
geteuid()	sendto()	wait()
getgid()	setgid()	waitpid()
getgroups()	setpgid()	write()
getpeername()	setsid()	

Functions not in the previous table are not asynchronous-safe, and should not be called from a signal hander.

Example - Call to `printf()` Inside Signal Handler

```
#include <signal.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
```

```
#include <setjmp.h>
#include <syslog.h>
#include <unistd.h>

#define SIZE20 20

extern volatile sig_atomic_t e_flag;

void display_info(const char *info)
{
    if (info)
    {
        (void)fputs(info, stderr);
    }
}

void sig_handler(int signum)
{
    /* Call function printf() that is not
    asynchronous-safe */
    printf("signal %d received.", signum);
    e_flag = 1;
}

int main(void)
{
    e_flag = 0;
    if (signal(SIGINT, sig_handler) == SIG_ERR)
    {
        /* Handle error */
    }
    char *info = (char *)calloc(SIZE20, sizeof(char));
    if (info == NULL)
    {
        /* Handle Error */
    }
    while (!e_flag)
    {
        /* Main loop program code */
        display_info(info);
        /* More program code */
    }
    free(info);
    info = NULL;
```

```
    return 0;
}
```

In this example, `sig_handler` calls `printf()` when catching a signal. If the handler catches another signal while `printf()` is executing, the behavior of the program is undefined.

Correction — Set Flag Only in Signal Handler

Use your signal handler to set only the value of a flag. `e_flag` is of type volatile `sig_atomic_t`. `sig_handler` can safely access it asynchronously.

```
#include <signal.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <setjmp.h>
#include <syslog.h>
#include <unistd.h>

#define SIZE20 20

extern volatile sig_atomic_t e_flag;

void display_info(const char *info)
{
    if (info)
    {
        (void)fputs(info, stderr);
    }
}

void sig_handler1(int signum)
{
    int s0 = signum;
    e_flag = 1;
}

int func(void)
{
    e_flag = 0;
    if (signal(SIGINT, sig_handler1) == SIG_ERR)
```

```
    {
        /* Handle error */
    }
    char *info = (char *)calloc(SIZE20, 1);
    if (info == NULL)
    {
        /* Handle error */
    }
    while (!e_flag)
    {
        /* Main loop program code */
        display_info(info);
        /* More program code */
    }
    free(info);
    info = NULL;
    return 0;
}
```

Function called from signal handler not asynchronous-safe (strict)

Description

Function called from signal handler not asynchronous-safe (strict) occurs when a signal handler calls a function that is not asynchronous-safe according to the C standard. An asynchronous-safe function can be interrupted at any point in its execution, then called again without causing an inconsistent state. It can also correctly handle global data that might be in an inconsistent state.

When you select the checker **Function called from signal handler not asynchronous-safe**, the checker detects calls to functions that are not asynchronous-safe according to the POSIX standard. **Function called from signal handler not asynchronous-safe (strict)** does not raise a defect for these cases. **Function called from signal handler not asynchronous-safe (strict)** raises a defect for functions that are asynchronous-safe according to the POSIX standard but not according to the C standard.

If a signal handler calls another function that calls an asynchronous-unsafe function, the defect appears on the function call in the signal handler. The defect traceback shows the full path from the signal handler to the asynchronous-unsafe function.

Risk

When a signal handler is invoked, the execution of the program is interrupted. After the handler is finished, program execution resumes at the point of interruption. If a function is executing at the time of the interruption, calling it from within the signal handler is undefined behavior, unless it is asynchronous-safe.

Fix

The C standard defines the following functions as asynchronous-safe. You can call these functions from a signal handler:

- `abort()`
- `_Exit()`
- `quick_exit()`
- `signal()`

Example - Call to `raise()` Inside Signal Handler

```
#include <signal.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <setjmp.h>
#include <syslog.h>
#include <unistd.h>

void SIG_ERR_handler(int signum)
{
    int s0 = signum;
    /* SIGTERM specific handling */
}

void sig_handler(int signum)
{
    int s0 = signum;
    /* Call raise() */
    if (raise(SIGTERM) != 0) {
        /* Handle error */
    }
}

int finc(void)
```

```
{
    if (signal(SIGTERM, SIG_ERR_handler) == SIG_ERR)
    {
        /* Handle error */
    }
    if (signal(SIGINT, sig_handler) == SIG_ERR)
    {
        /* Handle error */
    }
    /* Program code */
    if (raise(SIGINT) != 0)
    {
        /* Handle error */
    }
    /* More code */
    return 0;
}
```

In this example, `sig_handler` calls `raise()` when catching a signal. If the handler catches another signal while `raise()` is executing, the behavior of the program is undefined.

Correction — Remove Call to `raise()` in Signal Handler

According to the C standard, the only functions that you can safely call from a signal handler are `abort()`, `_Exit()`, `quick_exit()`, and `signal()`.

```
#include <signal.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <setjmp.h>
#include <syslog.h>
#include <unistd.h>

void SIG_ERR_handler(int signum)
{
    int s0 = signum;
    /* SIGTERM specific handling */
}
void sig_handler(int signum)
{
```

```
    int s0 = signum;


}

int func(void)
{
    if (signal(SIGTERM, SIG_ERR_handler) == SIG_ERR)
    {
        /* Handle error */
    }
    if (signal(SIGINT, sig_handler) == SIG_ERR)
    {
        /* Handle error */
    }
    /* Program code */
    if (raise(SIGINT) != 0)
    {
        /* Handle error */
    }
    /* More code */
    return 0;
}
```

Check Information

Group: Rule 11. Signals (SIG)

See Also

External Websites

SIG30-C

Introduced in R2019a

CERT C: Rule SIG31-C

Do not access shared objects in signal handlers

Description

Rule Definition

Do not access shared objects in signal handlers.

Examples

Shared data access within signal handler

Description

Shared data access within signal handler occurs when you access or modify a shared object inside a signal handler.

Risk

When you define a signal handler function to access or modify a shared object, the handler accesses or modifies the shared object when it receives a signal. If another function is already accessing the shared object, that function causes a race condition and can leave the data in an inconsistent state.

Fix

To access or modify shared objects inside a signal handler, check that the objects are lock-free atomic, or, if they are integers, declare them as `volatile sig_atomic_t`.

Example - `int` Variable Access in Signal Handler

```
#include <signal.h>
#include <stdlib.h>
#include <string.h>
```

```
/* declare global variable. */
int e_flag;

void sig_handler(int signum)
{
    /* Signal handler accesses variable that is not
    of type volatile sig_atomic_t. */
    e_flag = signum;
}

int func(void)
{
    if (signal(SIGINT, sig_handler) == SIG_ERR)
    {
        /* Handle error */
        abort();
    }
    /* Program code */
    if (raise(SIGINT) != 0)
    {
        /* Handle error */
        abort();
    }
    /* More code */
    return 0;
}
```

In this example, `sig_handler` accesses `e_flag`, a variable of type `int`. A concurrent access by another function can leave `e_flag` in an inconsistent state.

Correction — Declare Variable of Type `volatile sig_atomic_t`

Before you access a shared variable from a signal handler, declare the variable with type `volatile sig_atomic_t` instead of `int`. You can safely access variables of this type asynchronously.

```
#include <signal.h>
#include <stdlib.h>
#include <string.h>

/* Declare variable of type volatile sig_atomic_t. */
```

```
volatile sig_atomic_t e_flag;
void sig_handler(int signum)
{
    /* Use variable of proper type inside signal handler. */
    e_flag = signum;

}

int func(void)
{
    if (signal(SIGINT, sig_handler) == SIG_ERR)
    {
        /* Handle error */
        abort();
    }
    /* Program code */
    if (raise(SIGINT) != 0)
    {
        /* Handle error */
        abort();
    }
    /* More code */
    return 0;
}
```

Check Information

Group: Rule 11. Signals (SIG)

See Also

External Websites

SIG31-C

Introduced in R2019a

CERT C: Rule SIG34-C

Do not call signal() from within interruptible signal handlers

Description

Rule Definition

Do not call signal() from within interruptible signal handlers.

Examples

Signal call from within signal handler

Description

Signal call from within signal handler occurs when you call `signal()` from a nonpersistent signal handler on a Windows platform.

Risk

A nonpersistent signal handler is reset after catching a signal. The handler does not catch subsequent signals unless the handler is reestablished by calling `signal()`. A nonpersistent signal handler on a Windows platform is reset to `SIG_DFL`. If another signal interrupts the execution of the handler, that signal can cause a race condition between `SIG_DFL` and the existing signal handler. A call to `signal()` can also result in an infinite loop inside the handler.

Fix

Do not call `signal()` from a signal handler on Windows platforms.

Example - `signal()` Called from Signal Handler

```
#include <stdio.h>
#include <stdlib.h>
```

```
#include <signal.h>
#include <unistd.h>



volatile sig_atomic_t e_flag = 0;

void sig_handler(int signum)
{
    int s0 = signum;
    e_flag = 1;

    /* Call signal() to reestablish sig_handler
    upon receiving SIG_ERR. */

    if (signal(s0, sig_handler) == SIG_ERR)
    {
        /* Handle error */
    }
}

void func(void)
{
        if (signal(SIGINT, sig_handler) == SIG_ERR)
        {
            /* Handle error */

        }
  /* more code */
}
```

In this example, the definition of `sig_handler()` includes a call to `signal()` when the handler catches `SIG_ERR`. On Windows platforms, signal handlers are nonpersistent. This code can result in a race condition.

Correction — Do Not Call `signal()` from Signal Handler

If your code requires the use of a persistent signal handler on a Windows platform, use a persistent signal handler after performing a thorough risk analysis.

```
#include <stdio.h>
#include <stdlib.h>
#include <signal.h>
```

```
#include <unistd.h>


volatile sig_atomic_t e_flag = 0;


void sig_handler(int signum)
{
    int s0 = signum;
    e_flag = 1;
    /* No call to signal() */
}

int main(void)
{

        if (signal(SIGINT, sig_handler) == SIG_ERR)
        {
            /* Handle error */

        }
}
```

Check Information

Group: Rule 11. Signals (SIG)

See Also

External Websites

SIG34-C

Introduced in R2019a

CERT C: Rule SIG35-C

Do not return from a computational exception signal handler

Description

Rule Definition

Do not return from a computational exception signal handler.

Examples

Return from computational exception signal handler

Description

Return from computational exception signal handler occurs when a signal handler returns after catching a computational exception signal `SIGFPE`, `SIGILL`, or `SIGSEGV`.

Risk

A signal handler that returns normally from a computational exception is undefined behavior. Even if the handler attempts to fix the error that triggered the signal, the program can behave unexpectedly.

Fix

Check the validity of the values of your variables before the computation to avoid using a signal handler to catch exceptions. If you cannot avoid a handler to catch computation exception signals, call `abort()`, `quick_exit()`, or `_Exit()` in the handler to stop the program.

Example - Signal Handler Return from Division by Zero

```
#include <errno.h>
#include <limits.h>
```

```
#include <signal.h>
#include <stdlib.h>

static volatile sig_atomic_t denom;
/* Declare signal handler to catch division by zero
computation error. */
void sig_handler(int s)
{
    int s0 = s;
    if (denom == 0)
    {
        denom = 1;
    }
    /* Normal return from computation exception
    signal */
    return;
}


long func(int v)
{
    denom = (sig_atomic_t)v;

        if (signal(SIGFPE, sig_handler) == SIG_ERR)
        {
            /* Handle error */
        }

    long result = 100 / (long)denom;
    return result;
}
```

In this example, `sig_handler` is declared to handle a division by zero computation error. The handler changes the value of `denom` if it is zero and returns, which is undefined behavior.

Correction — Call `abort()` to Terminate Program

After catching a computational exception, call `abort()` from `sig_handler` to exit the program without further error.

```
#include <errno.h>
#include <limits.h>
```

```
#include <signal.h>
#include <stdlib.h>

static volatile sig_atomic_t denom;
/* Declare signal handler to catch division by zero
computation error. */

void sig_handler(int s)
{
    int s0 = s;
    /* call to abort() to exit the program */
    abort();
}

long func(int v)
{
    denom = (sig_atomic_t)v;

        if (signal(SIGFPE, sig_handler) == SIG_ERR)
        {
            /* Handle error */
        }

    long result = 100 / (long)denom;
    return result;
}
```

Check Information

Group: Rule 11. Signals (SIG)

See Also

External Websites

SIG35-C

Introduced in R2019a

Rule 12. Error Handling (ERR)

CERT C: Rule ERR30-C

Set errno to zero before calling a library function known to set errno, and check errno only after the function returns a value indicating failure

Description

Rule Definition

Set errno to zero before calling a library function known to set errno, and check errno only after the function returns a value indicating failure.

Examples

Misuse of errno

Description

Misuse of errno occurs when you check `errno` for error conditions in situations where checking `errno` does not guarantee the absence of errors. In some cases, checking `errno` can lead to false positives.

For instance, you check `errno` following calls to the functions:

- `fopen`: If you follow the ISO Standard, the function might not set `errno` on errors.
- `atof`: If you follow the ISO Standard, the function does not set `errno`.
- `signal`: The `errno` value indicates an error only if the function returns the `SIG_ERR` error indicator.

Risk

The ISO C Standard does not enforce that these functions set `errno` on errors. Whether the functions set `errno` or not is implementation-dependent.

To detect errors, if you check `errno` alone, the validity of this check also becomes implementation-dependent.

In some cases, the `errno` value indicates an error only if the function returns a specific error indicator. If you check `errno` before checking the function return value, you can see false positives.

Fix

For information on how to detect errors, see the documentation for that specific function.

Typically, the functions return an out-of-band error indicator to indicate errors. For instance:

- `fopen` returns a null pointer if an error occurs.
- `signal` returns the `SIG_ERR` error indicator and sets `errno` to a positive value. Check `errno` only after you have checked the function return value.

Example - Incorrectly Checking for `errno` After `fopen` Call

```
#include <stdio.h>
#include <stdlib.h>
#include <errno.h>

#define fatal_error() abort()

const char *temp_filename = "/tmp/demo.txt";

FILE *func()
{
    FILE *fileptr;
    errno = 0;
    fileptr = fopen(temp_filename, "w+b");
    if (errno != 0) {
        if (fileptr != NULL) {
            (void)fclose(fileptr);
        }
        /* Handle error */
        fatal_error();
    }
    return fileptr;
}
```

In this example, `errno` is the first variable that is checked after a call to `fopen`. You might expect that `fopen` changes `errno` to a nonzero value if an error occurs. If you run this code with an implementation of `fopen` that does not set `errno` on errors, you might

miss an error condition. In this situation, `fopen` can return a null pointer that escapes detection.

Correction — Check Return Value of `fopen` After Call

One possible correction is to only check the return value of `fopen` for a null pointer.

```
#include <stdio.h>
#include <stdlib.h>
#include <errno.h>

#define fatal_error() abort()

const char *temp_filename = "/tmp/demo.txt";

FILE *func()
{
    FILE *fileptr;
    fileptr = fopen(temp_filename, "w+b");
    if (fileptr == NULL) {
        fatal_error();
    }
    return fileptr;
}
```

Errno not reset

Description

Errno not reset occurs when you do not reset `errno` before calling a function that sets `errno` to indicate error conditions. However, you check `errno` for those error conditions after the function call.

Risk

The `errno` is not clean and can contain values from a previous call. Checking `errno` for errors can give the false impression that an error occurred.

`errno` is set to zero at program startup but subsequently, `errno` is not reset by a C standard library function. You must explicitly set `errno` to zero when required.

Fix

Before calling a function that sets `errno` to indicate error conditions, reset `errno` to zero explicitly.

Example - `errno` Not Reset Before Call to `strtod`

```
#include <stdio.h>
#include <stdlib.h>
#include <errno.h>
#include <float.h>

#define fatal_error() abort()

double func(const char *s1, const char *s2)
{
    double f1;
    f1 = strtod (s1, NULL);
    if (0 == errno) {
      double f2 = strtod (s2, NULL);
        if (0 == errno) {
            long double result = (long double)f1 + f2;
            if ((result <= (long double)DBL_MAX) && (result >= (long double)-DBL_MAX))
                  {
                return (double)result;
            }
        }
    }
    fatal_error();
    return 0.0;
}
```

In this example, `errno` is not reset to 0 before the first call to `strtod`. Checking `errno` for 0 later can lead to a false positive.

Correction — Reset `errno` Before Call

One possible correction is to reset `errno` to 0 before calling `strtod`.

```
#include <stdio.h>
#include <stdlib.h>
#include <errno.h>
#include <float.h>
```

```
#define fatal_error() abort()

double func(const char *s1, const char *s2)
{
    double f1;
    errno = 0;
    f1 = strtod (s1, NULL);
    if (0 == errno) {
      double f2 = strtod (s2, NULL);
        if (0 == errno) {
            long double result = (long double)f1 + f2;
            if ((result <= (long double)DBL_MAX) && (result >= (long double)-DBL_MAX))
              {
                return (double)result;
            }
        }
    }
    fatal_error();
    return 0.0;
}
```

Check Information

Group: Rule 12. Error Handling (ERR)

See Also

External Websites

ERR30-C

Introduced in R2019a

CERT C: Rule ERR32-C

Do not rely on indeterminate values of errno

Description

Rule Definition

Do not rely on indeterminate values of errno.

Examples

Misuse of errno in a signal handler

Description

Misuse of errno in a signal handler occurs when you call one of these functions in a signal handler:

- `signal`: You call the `signal` function in a signal handler and then read the value of `errno`.

  For instance, the signal handler function `handler` calls `signal` and then calls `perror`, which reads `errno`.

  ```
  void handler(int signum) {
    pfv old_handler = signal(signum, SIG_DFL);
    if (old_handler == SIG_ERR) {
      perror("SIGINT handler");
    }
  }
  ```

- `errno`-setting POSIX function: You call an `errno`-setting POSIX function in a signal handler but do not restore `errno` when returning from the signal handler.

  For instance, the signal handler function `handler` calls `waitpid`, which changes `errno`, but does not restore `errno` before returning.

```
void handler(int signum) {
  int rc = waitpid(-1, NULL, WNOHANG);
  if (ECHILD != errno) {
  }
}
```

Risk

In each case that the checker flags, you risk relying on an indeterminate value of `errno`.

- `signal`: If the call to `signal` in a signal handler fails, the value of `errno` is indeterminate (see C11 Standard, Sec. 7.14.1.1). If you rely on a specific value of `errno`, you can see unexpected results.
- `errno`-setting POSIX function: An `errno`-setting function sets `errno` on failure. If you read `errno` after a signal handler is called and the signal handler itself calls an `errno`-setting function, you can see unexpected results.

Fix

Avoid situations where you risk relying on an indeterminate value of `errno`.

- `signal`: After calling the `signal` function in a signal handler, do not read `errno` or use a function that reads `errno`.
- `errno`-setting POSIX function: Before calling an `errno`-setting function in a signal handler, save `errno` to a temporary variable. Restore `errno` from this variable before returning from the signal handler.

Example - Reading `errno` After `signal` Call in Signal Handler

```
#include <signal.h>
#include <stdlib.h>
#include <stdio.h>

#define fatal_error() abort()

void handler(int signum) {
    if (signal(signum, SIG_DFL) == SIG_ERR) {
        perror("SIGINT handler");
    }
}

int func(void) {
    if (signal(SIGINT, handler) == SIG_ERR) {
```

```
        /* Handle error */
        fatal_error();
    }
    /* Program code */
    if (raise(SIGINT) != 0) {
        /* Handle error */
        fatal_error();
    }
    return 0;
}
```

In this example, the function `handler` is called to handle the `SIGINT` signal. In the body of `handler`, the `signal` function is called. Following this call, the value of `errno` is indeterminate. The checker raises a defect when the `perror` function is called because `perror` relies on the value of `errno`.

Correction — Avoid Reading `errno` After `signal` Call

One possible correction is to not read `errno` after calling the `signal` function in a signal handler. The corrected code here calls the `abort` function via the `fatal_error` macro instead of the `perror` function.

```
#include <signal.h>
#include <stdlib.h>
#include <stdio.h>

#define fatal_error() abort()

void handler(int signum) {
    if (signal(signum, SIG_DFL) == SIG_ERR) {
        fatal_error();
    }
}

int func(void) {
    if (signal(SIGINT, handler) == SIG_ERR) {
        /* Handle error */
        fatal_error();
    }
    /* Program code */
    if (raise(SIGINT) != 0) {
        /* Handle error */
        fatal_error();
    }
```

```
    return 0;
}
```

Check Information

Group: Rule 12. Error Handling (ERR)

See Also

External Websites

ERR32-C

Introduced in R2019a

CERT C: Rule ERR33-C

Detect and handle standard library errors

Description

Rule Definition

Detect and handle standard library errors.

Examples

Errno not checked

Description

Errno not checked occurs when you call a function that sets `errno` to indicate error conditions, but do not check `errno` after the call. For these functions, checking `errno` is the only reliable way to determine if an error occurred.

Functions that set `errno` on errors include:

- `fgetwc`, `strtol`, and `wcstol`.

  For a comprehensive list of functions, see documentation about errno.
- POSIX `errno`-setting functions such as `encrypt` and `setkey`.

Risk

To see if the function call completed without errors, check `errno` for error values.

The return values of these `errno`-setting functions do not indicate errors. The return value can be one of the following:

- `void`

- Even if an error occurs, the return value can be the same as the value from a successful call. Such return values are called in-band error indicators.

You can determine if an error occurred only by checking `errno`.

For instance, `strtol` converts a string to a long integer and returns the integer. If the result of conversion overflows, the function returns `LONG_MAX` and sets `errno` to `ERANGE`. However, the function can also return `LONG_MAX` from a successful conversion. Only by checking `errno` can you distinguish between an error and a successful conversion.

Fix

Before calling the function, set `errno` to zero.

After the function call, to see if an error occurred, compare `errno` to zero. Alternatively, compare `errno` to known error indicator values. For instance, `strtol` sets `errno` to `ERANGE` to indicate errors.

The error message in the Polyspace result shows the error indicator value that you can compare to.

Example - `errno` Not Checked After Call to `strtol`

```
#include<stdio.h>
#include<stdlib.h>
#include<errno.h>

int main(int argc, char *argv[]) {
    char *str, *endptr;
    int base;

    str = argv[1];
    base = 10;

    long val = strtol(str, &endptr, base);
    printf("Return value of strtol() = %ld\n", val);
}
```

You are using the return value of `strtol` without checking `errno`.

Correction — Check `errno` After Call

Before calling `strtol`, set `errno` to zero . After a call to `strtol`, check the return value for `LONG_MIN` or `LONG_MAX` and `errno` for `ERANGE`.

```
#include<stdlib.h>
#include<stdio.h>
#include<errno.h>
#include<limits.h>

int main(int argc, char *argv[]) {
    char *str, *endptr;
    int base;

    str = argv[1];
    base = 10;

    errno = 0;
    long val = strtol(str, &endptr, base);
    if((val == LONG_MIN || val == LONG_MAX) && errno == ERANGE) {
         printf("strtol error");
         exit(EXIT_FAILURE);
    }
    printf("Return value of strtol() = %ld\n", val);
}
```

Returned value of a sensitive function not checked

Description

Returned value of a sensitive function not checked occurs when you call sensitive standard functions, but you:

- Ignore the return value.
- Use an output or a return value without testing the validity of the return value.

For this defect, two type of functions are considered: ***sensitive*** and ***critical sensitive***.

A ***sensitive*** function is a standard function that can encounter:

- Exhausted system resources (for example, when allocating resources)
- Changed privileges or permissions
- Tainted sources when reading, writing, or converting data from external sources
- Unsupported features despite an existing API

A ***critical sensitive*** function is a sensitive function that performs one of these critical or vulnerable tasks:

- Set privileges (for example, `setuid`)
- Create a jail (for example, `chroot`)
- Create a process (for example, `fork`)
- Create a thread (for example, `pthread_create`)
- Lock or unlock mutex (for example, `pthread_mutex_lock`)
- Lock or unlock memory segments (for example, `mlock`)

Risk

If you do not check the return value of functions that perform sensitive or critical sensitive tasks, your program can behave unexpectedly. Errors from these functions can propagate throughout the program causing incorrect output, security vulnerabilities, and possibly system failures.

Fix

Before continuing with the program, test the return value of *critical sensitive* functions.

For *sensitive functions*, you can explicitly ignore a return value by casting the function to `void`. Polyspace does not raise this defect for sensitive functions cast to void. This resolution is not accepted for *critical sensitive functions* because they perform more vulnerable tasks.

Example - Sensitive Function Return Ignored

```
#include <pthread.h>

void initialize() {
    pthread_attr_t attr;

    pthread_attr_init(&attr);
}
```

This example shows a call to the sensitive function `pthread_attr_init`. The return value of `pthread_attr_init` is ignored, causing a defect.

Correction — Cast Function to `(void)`

One possible correction is to cast the function to void. This fix informs Polyspace and any reviewers that you are explicitly ignoring the return value of the sensitive function.

```
#include <pthread.h>

void initialize() {
    pthread_attr_t attr;

    (void)pthread_attr_init(&attr);
}
```

Correction — Test Return Value

One possible correction is to test the return value of `pthread_attr_init` to check for errors.

```
#include <pthread.h>
#include <stdlib.h>
#define fatal_error() abort()

void initialize() {
    pthread_attr_t attr;
    int result;

    result = pthread_attr_init(&attr);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }
}
```

Example - Critical Function Return Ignored

```
#include <pthread.h>
extern void *start_routine(void *);

void returnnotchecked() {
    pthread_t thread_id;
    pthread_attr_t attr;
    void *res;

    (void)pthread_attr_init(&attr);
    (void)pthread_create(&thread_id, &attr, &start_routine, ((void *)0));
    pthread_join(thread_id,  &res);
}
```

In this example, two critical functions are called: `pthread_create` and `pthread_join`. The return value of the `pthread_create` is ignored by casting to void, but because

`pthread_create` is a critical function (not just a sensitive function), Polyspace does not ignore this *Return value of a sensitive function not checked* defect. The other critical function, `pthread_join`, returns value that is ignored implicitly. `pthread_join` uses the return value of `pthread_create`, which was not checked.

Correction — Test the Return Value of Critical Functions

The correction for this defect is to check the return value of these critical functions to verify the function performed as expected.

```
#include <pthread.h>
#include <stdlib.h>
#define fatal_error() abort()

extern void *start_routine(void *);

void returnnotchecked() {
    pthread_t thread_id;
    pthread_attr_t attr;
    void *res;
    int result;

    (void)pthread_attr_init(&attr);
    result = pthread_create(&thread_id, &attr, &start_routine, NULL);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }

    result = pthread_join(thread_id,  &res);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }
}
```

Unprotected dynamic memory allocation

Description

Unprotected dynamic memory allocation occurs when you do not check after dynamic memory allocation whether the memory allocation succeeded.

Risk

When memory is dynamically allocated using `malloc`, `calloc`, or `realloc`, it returns a value `NULL` if the requested memory is not available. If the code following the allocation accesses the memory block without checking for this `NULL` value, this access is not protected from failures.

Fix

Check the return value of `malloc`, `calloc`, or `realloc` for NULL before accessing the allocated memory location.

```
int *ptr = malloc(size * sizeof(int));

if(ptr) /* Check for NULL */
{
   /* Memory access through ptr */
}
```

Example - Unprotected dynamic memory allocation error

```
#include <stdlib.h>

void Assign_Value(void)
{
  int* p = (int*)calloc(5, sizeof(int));

  *p = 2;
  /* Defect: p is not checked for NULL value */

  free(p);
}
```

If the memory allocation fails, the function `calloc` returns `NULL` to `p`. Before accessing the memory through `p`, the code does not check whether `p` is `NULL`

Correction — Check for NULL Value

One possible correction is to check whether `p` has value `NULL` before dereference.

```
#include <stdlib.h>

void Assign_Value(void)
 {
```

```
  int* p = (int*)calloc(5, sizeof(int));

  /* Fix: Check if p is NULL */
  if(p!=NULL) *p = 2;

  free(p);
}
```

Check Information

Group: Rule 12. Error Handling (ERR)

See Also

External Websites

ERR33-C

Introduced in R2019a

CERT C: Rule ERR34-C

Detect errors when converting a string to a number

Description

Rule Definition

Detect errors when converting a string to a number.

Examples

Unsafe conversion from string to numerical value

Description

Unsafe conversion from string to numerical value detects conversions from strings to integer or floating-point values. If your conversion method does not include robust error handling, a defect is raised.

Risk

Converting a string to numerical value can cause data loss or misinterpretation. Without validation of the conversion or error handling, your program continues with invalid values.

Fix

- Add additional checks to validate the numerical value.
- Use a more robust string-to-numeric conversion function such as `strtol`, `strtoll`, `strtoul`, or `strtoull`.

Example - Conversion With `atoi`

```
#include <stdio.h>
#include <stdlib.h>
```

```
#include <string.h>

static int demo_check_string_not_empty(char *s)
{
    if (s != NULL)
        return strlen(s) > 0; /* check string null-terminated and not empty */
    else
        return 0;
}

int unsafestrtonumeric(char* argv1)
{
    int s = 0;
    if (demo_check_string_not_empty(argv1))
    {
        s = atoi(argv1);
    }
    return s;
}
```

In this example, `argv1` is converted to an integer with `atoi`. `atoi` does not provide errors for an invalid integer string. The conversion can fail unexpectedly.

Correction — Use `strtol` instead

One possible correction is to use `strtol` to validate the input string and the converted integer.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <limits.h>
#include <errno.h>

static int demo_check_string_not_empty(char *s)
{
    if (s != NULL)
        return strlen(s) > 0; /* check string null-terminated and not empty */
    else
        return 0;
}

int unsafestrtonumeric(char *argv1)
{
    char *c_str = argv1;
```

```
    char *end;
    long sl;

    if (demo_check_string_not_empty(c_str))
    {
        errno = 0; /* set errno for error check */
        sl = strtol(c_str, &end, 10);
        if (end == c_str)
        {
            (void)fprintf(stderr, "%s: not a decimal number\n", c_str);
        }
        else if ('\0' != *end)
        {
            (void)fprintf(stderr, "%s: extra characters: %s\n", c_str, end);
        }
        else if ((LONG_MIN == sl || LONG_MAX == sl) && ERANGE == errno)
        {
            (void)fprintf(stderr, "%s out of range of type long\n", c_str);
        }
        else if (sl > INT_MAX)
        {
            (void)fprintf(stderr, "%ld greater than INT_MAX\n", sl);
        }
        else if (sl < INT_MIN)
        {
            (void)fprintf(stderr, "%ld less than INT_MIN\n", sl);
        }
        else
        {
            return (int)sl;
        }
    }
    return 0;
}
```

Check Information

Group: Rule 12. Error Handling (ERR)

See Also

External Websites

ERR34-C

Introduced in R2019a

Rule 14. Concurrency (CON)

CERT C: Rule CON30-C

Clean up thread-specific storage

Description

Rule Definition

Clean up thread-specific storage.

Examples

Thread-specific memory leak

Description

Thread-specific memory leak occurs when you do not free thread-specific dynamically allocated memory before the end of a thread.

To create thread-specific storage, you generally do these steps:

1. You create a key for thread-specific storage.
2. You create the threads.
3. In each thread, you allocate storage dynamically and then associate the key with this storage.

   After the association, you can read the stored data later using the key.
4. Before the end of the thread, you free the thread-specific memory using the key.

The checker flags execution paths in the thread where the last step is missing.

The checker works on these families of functions:

- `tss_get` and `tss_set` (C11)

- `pthread_getspecific` and `pthread_setspecific` (POSIX)

Risk

The data stored in the memory is available to other processes even after the threads end (memory leak). Besides security vulnerabilities, memory leaks can shrink the amount of available memory and reduce performance.

Fix

Free dynamically allocated memory before the end of a thread.

You can explicitly free dynamically allocated memory with functions such as `free`.

Alternatively, when you create a key, you can associate a destructor function with the key. The destructor function is called with the key value as argument at the end of a thread. In the body of the destructor function, you can free any memory associated with the key. If you use this method, Bug Finder still flags a defect. Ignore this defect with appropriate comments. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Memory Not Freed at End of Thread

```
#include <threads.h>
#include <stdlib.h>

/* Global key to the thread-specific storage */
tss_t key;
enum { MAX_THREADS = 3 };


int add_data(void) {
  int *data = (int *)malloc(2 * sizeof(int));
  if (data == NULL) {
    return -1;  /* Report error  */
  }
  data[0] = 0;
  data[1] = 1;

  if (thrd_success != tss_set(key, (void *)data)) {
    /* Handle error */
  }
  return 0;
}
```

```
void print_data(void) {
  /* Get this thread's global data from key */
  int *data = tss_get(key);

  if (data != NULL) {
    /* Print data */
  }
}

int func(void *dummy) {
  if (add_data() != 0) {
    return -1;  /* Report error */
  }
  print_data();
  return 0;
}

int main(void) {
  thrd_t thread_id[MAX_THREADS];

  /* Create the key before creating the threads */
  if (thrd_success != tss_create(&key, NULL)) {
    /* Handle error */
  }

  /* Create threads that would store specific storage */
  for (size_t i = 0; i < MAX_THREADS; i++) {
    if (thrd_success != thrd_create(&thread_id[i], func, NULL)) {
      /* Handle error */
    }
  }

  for (size_t i = 0; i < MAX_THREADS; i++) {
    if (thrd_success != thrd_join(thread_id[i], NULL)) {
      /* Handle error */
    }
  }

  tss_delete(key);
  return 0;
}
```

In this example, the start function of each thread `func` calls two functions:

- `add_data`: This function allocates storage dynamically and associates the storage with a key using the `tss_set` function.
- `print_data`: This function reads the stored data using the `tss_get` function.

At the points where `func` returns, the dynamically allocated storage has not been freed.

Correction — Free Dynamically Allocated Memory Explicitly

One possible correction is to free dynamically allocated memory explicitly before leaving the start function of a thread. See the highlighted change in the corrected version.

In this corrected version, a defect still appears on the `return` statement in the error handling section of `func`. The defect cannot occur in practice because the error handling section is entered only if dynamic memory allocation fails. Ignore this remaining defect with appropriate comments. See "Address Polyspace Results Through Bug Fixes or Comments".

```
#include <threads.h>
#include <stdlib.h>

/* Global key to the thread-specific storage */
tss_t key;
enum { MAX_THREADS = 3 };


int add_data(void) {
  int *data = (int *)malloc(2 * sizeof(int));
  if (data == NULL) {
    return -1;  /* Report error  */
  }
  data[0] = 0;
  data[1] = 1;

  if (thrd_success != tss_set(key, (void *)data)) {
    /* Handle error */
  }
  return 0;
}

void print_data(void) {
  /* Get this thread's global data from key */
  int *data = tss_get(key);
```

```
  if (data != NULL) {
    /* Print data */
  }
}

int func(void *dummy) {
  if (add_data() != 0) {
    return -1;  /* Report error */
  }
  print_data();
  free(tss_get(key));
  return 0;
}

int main(void) {
  thrd_t thread_id[MAX_THREADS];

  /* Create the key before creating the threads */
  if (thrd_success != tss_create(&key, NULL)) {
    /* Handle error */
  }

  /* Create threads that would store specific storage */
  for (size_t i = 0; i < MAX_THREADS; i++) {
    if (thrd_success != thrd_create(&thread_id[i], func, NULL)) {
      /* Handle error */
    }
  }

  for (size_t i = 0; i < MAX_THREADS; i++) {
    if (thrd_success != thrd_join(thread_id[i], NULL)) {
      /* Handle error */
    }
  }

  tss_delete(key);
  return 0;
}
```

Check Information

Group: Rule 14. Concurrency (CON)

See Also

External Websites

CON30-C

Introduced in R2019a

CERT C: Rule CON31-C

Do not destroy a mutex while it is locked

Description

Rule Definition

Do not destroy a mutex while it is locked.

Examples

Destruction of locked mutex

Description

Destruction of locked mutex occurs when a task destroys a mutex after it is locked (and before it is unlocked). The locking and destruction can happen in the same task or different tasks.

Risk

A mutex is locked to protect shared variables from concurrent access. If a mutex is destroyed in the locked state, the protection does not apply.

Fix

To fix this defect, destroy the mutex only after you unlock it. It is a good design practice to:

- Initialize a mutex *before* creating the threads where you use the mutex.
- Destroy a mutex *after* joining the threads that you created.

On the **Result Details** pane, you see two events, the locking and destruction of the mutex, and the tasks that initiated the events. To navigate to the corresponding line in your source code, click the event.

Example - Locking and Destruction in Different Tasks

```
#include <pthread.h>

pthread_mutex_t lock1;
pthread_mutex_t lock2;
pthread_mutex_t lock3;

void t0 (void) {
  pthread_mutex_lock (&lock1);
  pthread_mutex_lock (&lock2);
  pthread_mutex_lock (&lock3);
  pthread_mutex_unlock (&lock2);
  pthread_mutex_unlock (&lock1);
  pthread_mutex_unlock (&lock3);
}

void t1 (void) {
  pthread_mutex_lock (&lock1);
  pthread_mutex_lock (&lock2);
  pthread_mutex_destroy (&lock3);
  pthread_mutex_unlock (&lock2);
  pthread_mutex_unlock (&lock1);
}
```

In this example, after task `t0` locks the mutex `lock3`, task `t1` can destroy it. The destruction occurs if the following events happen in sequence:

1. `t0` acquires `lock3`.
2. `t0` releases `lock2`.
3. `t0` releases `lock1`.
4. `t1` acquires the lock `lock1` released by `t0`.
5. `t1` acquires the lock `lock2` released by `t0`.
6. `t1` destroys `lock3`.

For simplicity, this example uses a mix of automatic and manual concurrency detection. The tasks `t0` and `t1` are manually specified as entry points by using the option `Tasks (-entry-points)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.The critical sections are

implemented through primitives `pthread_mutex_lock` and `pthread_mutex_unlock` that the software detects automatically. In practice, for entry point specification (thread creation), you will use primitives such as `pthread_create`. The next example shows how the defect can appear when you use `pthread_create`.

Correction — Place Lock-Unlock Pair Together in Same Critical Section as Destruction

The locking and destruction of `lock3` occurs inside the critical section imposed by `lock1` and `lock2`, but the unlocking occurs outside. One possible correction is to place the lock-unlock pair in the same critical section as the destruction of the mutex. Use one of these critical sections:

- Critical section imposed by `lock1` alone.
- Critical section imposed by `lock1` and `lock2`.

In this corrected code, the lock-unlock pair and the destruction is placed in the critical section imposed by `lock1` and `lock2`. When `t0` acquires `lock1` and `lock2`, `t1` has to wait for their release before it executes the instruction `pthread_mutex_destroy (&lock3);`. Therefore, `t1` cannot destroy mutex `lock3` in the locked state.

```
#include <pthread.h>

pthread_mutex_t lock1;
pthread_mutex_t lock2;
pthread_mutex_t lock3;

void t0 (void) {
  pthread_mutex_lock (&lock1);
  pthread_mutex_lock (&lock2);

  pthread_mutex_lock (&lock3);
  pthread_mutex_unlock (&lock3);

  pthread_mutex_unlock (&lock2);
  pthread_mutex_unlock (&lock1);
}

void t1 (void) {
  pthread_mutex_lock (&lock1);
  pthread_mutex_lock (&lock2);
```

```
  pthread_mutex_destroy (&lock3);

  pthread_mutex_unlock (&lock2);
  pthread_mutex_unlock (&lock1);
}
```

Example - Locking and Destruction in Start Routine of Thread

```
#include <pthread.h>

/* Define globally accessible variables and a mutex */
#define NUMTHREADS 4
pthread_t callThd[NUMTHREADS];
pthread_mutex_t lock;
void atomic_operation(void);

void *do_create(void *arg) {
    /* Creation thread */
    pthread_mutex_init(&lock, NULL);
    pthread_exit((void*) 0);
}

void *do_work(void *arg) {
    /* Worker thread */
    pthread_mutex_lock (&lock);
    atomic_operation();
    pthread_mutex_unlock (&lock);
    pthread_exit((void*) 0);
}

void *do_destroy(void *arg) {
    /* Destruction thread */
    pthread_mutex_destroy(&lock);
    pthread_exit((void*) 0);
}

int main (int argc, char *argv[]) {
   int i;
   void *status;
   pthread_attr_t attr;


   /* Create threads */
```

```
   pthread_attr_init(&attr);
   pthread_attr_setdetachstate(&attr, PTHREAD_CREATE_JOINABLE);

   /* Thread that initializes mutex */
   pthread_create(&callThd[0], &attr, do_create, NULL);

   /* Threads that use mutex for atomic operation*/
   for(i=0; i<NUMTHREADS-1; i++) {
      pthread_create(&callThd[i], &attr, do_work, (void *)i);
   }

   /* Thread that destroys mutex */
   pthread_create(&callThd[NUMTHREADS -1], &attr, do_destroy, NULL);

   pthread_attr_destroy(&attr);

   /* Join threads */
   for(i=0; i<NUMTHREADS; i++) {
      pthread_join(callThd[i], &status);
   }

   pthread_exit(NULL);
}
```

In this example, four threads are created. The threads are assigned different actions.

- The first thread `callThd[0]` initializes the mutex `lock`.
- The second and third threads, `callThd[1]` and `callThd[2]`, perform an atomic operation protected by the mutex `lock`.
- The fourth thread `callThd[3]` destroys the mutex `lock`.

The threads can interrupt each other. Therefore, immediately after the second or third thread locks the mutex, the fourth thread can destroy it.

Correction — Initialize and Destroy Mutex Outside Start Routine

One possible correction is to initialize and destroy the mutex in the `main` function outside the start routine of the threads. The threads perform only the atomic operation. You need two fewer threads because the mutex initialization and destruction threads are not required.

```
#include <pthread.h>
```

```
/* Define globally accessible variables and a mutex */
#define NUMTHREADS 2
pthread_t callThd[NUMTHREADS];
pthread_mutex_t lock;
void atomic_operation(void);

void *do_work(void *arg) {
   pthread_mutex_lock (&lock);
   atomic_operation();
   pthread_mutex_unlock (&lock);
   pthread_exit((void*) 0);
}

int main (int argc, char *argv[]) {
   int i;
   void *status;
   pthread_attr_t attr;


   /* Create threads */
   pthread_attr_init(&attr);
   pthread_attr_setdetachstate(&attr, PTHREAD_CREATE_JOINABLE);

   /* Initialize mutex */
   pthread_mutex_init(&lock, NULL);

   for(i=0; i<NUMTHREADS; i++) {
      pthread_create(&callThd[i], &attr, do_work, (void *)i);
   }

   pthread_attr_destroy(&attr);

   /* Join threads */
   for(i=0; i<NUMTHREADS; i++) {
      pthread_join(callThd[i], &status);
   }

   /* Destroy mutex */
   pthread_mutex_destroy(&lock);

   pthread_exit(NULL);
}
```

Correction — Use A Second Mutex To Protect Lock-Unlock Pair and Destruction

Another possible correction is to use a second mutex and protect the lock-unlock pair from the destruction. This corrected code uses the mutex `lock2` to achieve this protection. The second mutex is initialized in the `main` function outside the start routine of the threads.

```
#include <pthread.h>

/* Define globally accessible variables and a mutex */
#define NUMTHREADS 4
pthread_t callThd[NUMTHREADS];
pthread_mutex_t lock;
pthread_mutex_t lock2;
void atomic_operation(void);

void *do_create(void *arg) {
    /* Creation thread */
    pthread_mutex_init(&lock, NULL);
    pthread_exit((void*) 0);
}

void *do_work(void *arg) {
    /* Worker thread */
    pthread_mutex_lock (&lock2);
    pthread_mutex_lock (&lock);
    atomic_operation();
    pthread_mutex_unlock (&lock);
    pthread_mutex_unlock (&lock2);
    pthread_exit((void*) 0);
}

void *do_destroy(void *arg) {
    /* Destruction thread */
    pthread_mutex_lock (&lock2);
    pthread_mutex_destroy(&lock);
    pthread_mutex_unlock (&lock2);
    pthread_exit((void*) 0);
}


int main (int argc, char *argv[]) {
   int i;
   void *status;
```

```
    pthread_attr_t attr;


    /* Create threads */
    pthread_attr_init(&attr);
    pthread_attr_setdetachstate(&attr, PTHREAD_CREATE_JOINABLE);

    /* Initialize second mutex */
    pthread_mutex_init(&lock2, NULL);

    /* Thread that initializes first mutex */
    pthread_create(&callThd[0], &attr, do_create, NULL);

    /* Threads that use first mutex for atomic operation */
    /* The threads use second mutex to protect first from destruction in locked state*/
    for(i=0; i<NUMTHREADS-1; i++) {
       pthread_create(&callThd[i], &attr, do_work, (void *)i);
    }

    /* Thread that destroys first mutex */
    /* The thread uses the second mutex to prevent destruction of locked mutex */
    pthread_create(&callThd[NUMTHREADS -1], &attr, do_destroy, NULL);


    pthread_attr_destroy(&attr);

    /* Join threads */
    for(i=0; i<NUMTHREADS; i++) {
       pthread_join(callThd[i], &status);
    }

    /* Destroy second mutex */
    pthread_mutex_destroy(&lock2);

    pthread_exit(NULL);
}
```

Check Information

Group: Rule 14. Concurrency (CON)

See Also

External Websites

CON31-C

Introduced in R2019a

CERT C: Rule CON32-C

Prevent data races when accessing bit-fields from multiple threads

Description

Rule Definition

Prevent data races when accessing bit-fields from multiple threads.

Examples

Data race

Description

Data race occurs when:

1. Multiple tasks perform unprotected operations on a shared variable.
2. At least one task performs a write operation.
3. At least one operation is nonatomic. For data race on both atomic and nonatomic operations, see `Data race including atomic operations`.

   See also the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**. For more information, see the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Data race can result in unpredictable values of the shared variable because you do not control the order of the operations in different tasks.

Data races between two write operations are more serious than data races between a write and read operation. Two write operations can interfere with each other and result in

indeterminate values. To identify write-write conflicts, use the filters on the **Detail** column of the **Results List** pane. For these conflicts, the **Detail** column shows the additional line:

```
Variable value may be altered by write-write concurrent access.
```

See “Filter and Sort Results”.

Fix

To fix this defect, protect the operations on the shared variable using critical sections, temporal exclusion or another means. See the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server..

To identify existing protections that you can reuse, see the table and graphs associated with the result. The table shows each pair of conflicting calls. The **Access Protections** column shows existing protections on the calls. To see the function call sequence leading to the conflicts, click the  icon. For an example, see below.

Example - Unprotected Operation on Global Variable from Multiple Tasks

```
int var;
void begin_critical_section(void);
void end_critical_section(void);

void increment(void) {
    var++;
}

void task1(void)  {
      increment();
}

void task2(void)  {
      increment();
}

void task3(void)  {
     begin_critical_section();
     increment();
```

```
    end_critical_section();
}
```

In this example, to emulate multitasking behavior, specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	task1 task2 task3	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section	end_critical_section

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
  -entry-points task1,task2,task3
  -critical-section-begin begin_critical_section:cs1
  -critical-section-end end_critical_section:cs1
```

In this example, the tasks `task1`, `task2`, and `task3` call the function `increment`. `increment` contains the operation `var++` that can involve multiple machine instructions including:

- Reading `var`.
- Writing an increased value to `var`.

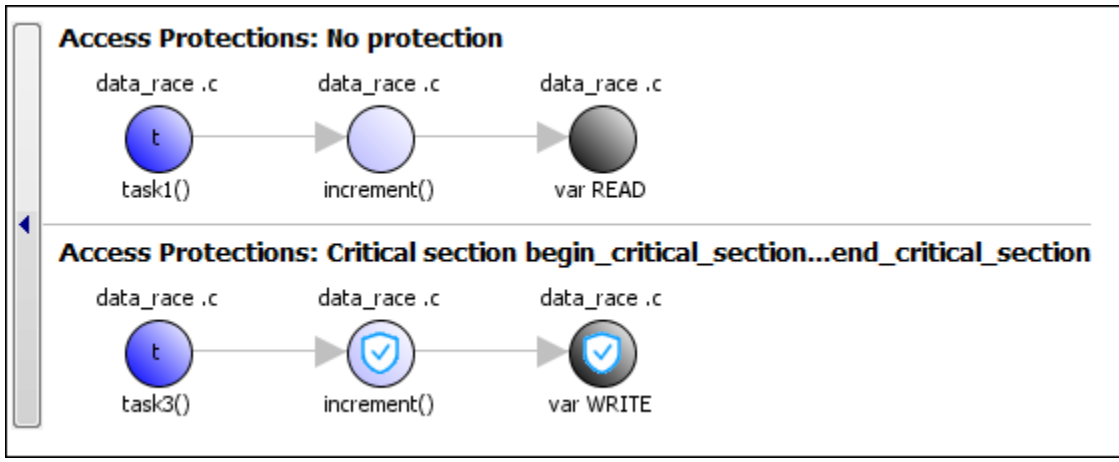
These machine instructions, when executed from `task1` and `task2`, can occur concurrently in an unpredictable sequence. For example, reading `var` from `task1` can occur either before or after writing to `var` from `task2`. Therefore the value of `var` can be unpredictable.

Though `task3` calls `increment` inside a critical section, other tasks do not use the same critical section. The operations in the critical section of `task3` are not mutually exclusive with operations in other tasks.

Therefore, the three tasks are operating on a shared variable without common protection. In your result details, you see each pair of conflicting function calls.

	Access	Access Protections	Task	File
	Read	No protection	task1()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	No protection	task2()	data_race .c
	Read	No protection	task1()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	**Critical section begin_critical_section...end_critical_section**	task3()	data_race .c
	Read	No protection	task2()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	**Critical section begin_critical_section...end_critical_section**	task3()	data_race .c

If you click the  icon, you see the function call sequence starting from the entry point to the read or write operation. You also see that the operation starting from `task3` is in a critical section. The **Access Protections** entry shows the lock and unlock function that begin and end the critical section. In this example, you see the functions `begin_critical_section` and `end_critical_section`.



Correction — Place Operation in Critical Section

One possible correction is to place the operation in critical section. You can implement the critical section in multiple ways. For instance:

- You can place `var++` in a critical section. When `task1` enters its critical section, the other tasks cannot enter their critical sections until `task1` leaves its critical section. The operation `var++` from the three tasks cannot interfere with each other.

  To implement the critical section, in the function `increment`, place the operation `var ++` between calls to `begin_critical_section` and `end_critical_section`.

```
int var;

void begin_critical_section(void);
void end_critical_section(void);

void increment(void) {
      begin_critical_section();
      var++;
      end_critical_section();
}

void task1(void)  {
      increment();
}

void task2(void)  {
      increment();
}

void task3(void)  {
      increment();
}
```

- You can place the call to `increment` in the same critical section in the three tasks. When `task1` enters its critical section, the other tasks cannot enter their critical sections until `task1` leaves its critical section. The calls to `increment` from the three tasks cannot interfere with each other.

  To implement the critical section, in each of the three tasks, call `increment` between calls to `begin_critical_section` and `end_critical_section`.

```
int var;

void begin_critical_section(void);
void end_critical_section(void);

void increment(void) {
      var++;
}

void task1(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}

void task2(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}

void task3(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}
```

Correction — Make Tasks Temporally Exclusive

Another possible correction is to make the tasks, `task1`, `task2` and `task3`, temporally exclusive. Temporally exclusive tasks cannot execute concurrently.

On the **Configuration** pane, specify the following additional options:

Option	Value
`Temporally exclusive tasks (-temporal-exclusions-file)`	`task1 task2 task3`

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
 polyspace-bug-finder
     -temporal-exclusions-file "C:\exclusions_file.txt"
```

where the file `C:\exclusions_file.txt` has the following line:

```
task1 task2 task3
```

Example - Unprotected Operation in Threads Created with `pthread_create`

```
#include <pthread.h>

pthread_mutex_t count_mutex;
long long count;


void* increment_count(void* args)
{
    count = count + 1;
    return NULL;
}

void* set_count(void *args)
{
    long long c;
    c = count;
    return NULL;
}

int main(void)
{
    pthread_t thread_increment;
    pthread_t thread_get;

    pthread_create(&thread_increment, NULL, increment_count, NULL);
    pthread_create(&thread_get, NULL, set_count, NULL);

    pthread_join(thread_get, NULL);
    pthread_join(thread_increment, NULL);

    return 1;
}
```

In this example, Bug Finder detects the creation of separate threads with `pthread_create`. The **Data race** defect is raised because the operation `count = count + 1` in the thread with id `thread_increment` conflicts with the operation `c = count` in the thread with id `thread_get`. The variable `count` is accessed in multiple threads without a common protection.

The two conflicting operations are nonatomic. The operation `c = count` is nonatomic on 32-bit targets. See the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server..

Correction — Protect Operations with `pthread_mutex_lock` and `pthread_mutex_unlock` Pair

To prevent concurrent access on the variable `count`, protect operations on `count` with a critical section. Use the functions `pthread_mutex_lock` and `pthread_mutex_unlock` to implement the critical section.

```
#include <pthread.h>

pthread_mutex_t count_mutex;
long long count;


void* increment_count(void* args)
{
    pthread_mutex_lock(&count_mutex);
    count = count + 1;
    pthread_mutex_unlock(&count_mutex);
    return NULL;
}

void* set_count(void *args)
{
    long long c;
    pthread_mutex_lock(&count_mutex);
    c = count;
    pthread_mutex_unlock(&count_mutex);
    return NULL;
}

int main(void)
{
    pthread_t thread_increment;
    pthread_t thread_get;
```

```
    pthread_create(&thread_increment, NULL, increment_count, NULL);
    pthread_create(&thread_get, NULL, set_count, NULL);

    pthread_join(thread_get, NULL);
    pthread_join(thread_increment, NULL);

    return 1;
}
```

Check Information

Group: Rule 14. Concurrency (CON)

See Also

External Websites

CON32-C

Introduced in R2019a

CERT C: Rule CON33-C

Avoid race conditions when using library functions

Description

Rule Definition

Avoid race conditions when using library functions.

Examples

Data race through standard library function call

Description

Data race through standard library function call occurs when:

1. Multiple tasks call the same standard library function.

   For instance, multiple tasks call the `strerror` function.
2. The calls are not protected using a common protection.

   For instance, the calls are not protected by the same critical section.

Functions flagged by this defect are not guaranteed to be reentrant. A function is reentrant if it can be interrupted and safely called again before its previous invocation completes execution. If a function is not reentrant, multiple tasks calling the function without protection can cause concurrency issues. For the list of functions that are flagged, see CON33-C: Avoid race conditions when using library functions.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**. For more information, see the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

The functions flagged by this defect are nonreentrant because their implementations can use global or static variables. When multiple tasks call the function without protection, the function call from one task can interfere with the call from another task. The two invocations of the function can concurrently access the global or static variables and cause unpredictable results.

The calls can also cause more serious security vulnerabilities, such as abnormal termination, denial-of-service attack, and data integrity violations.

Fix

To fix this defect, do one of the following:

- Use a reentrant version of the standard library function if it exists.

  For instance, instead of `strerror()`, use `strerror_r()` or `strerror_s()`. For alternatives to functions flagged by this defect, see the documentation for CON33-C.
- Protect the function calls using common critical sections or temporal exclusion.

  See `Critical section details (-critical-section-begin -critical-section-end)` and `Temporally exclusive tasks (-temporal-exclusions-file)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

  To identify existing protections that you can reuse, see the table and graphs associated with the result. The table shows each pair of conflicting calls. The **Access Protections** column shows existing protections on the calls. To see the function call sequence leading to the conflicts, click the  icon. For an example, see below.

Example - Unprotected Call to Standard Library Function from Multiple Tasks

```
#include <errno.h>
#include <stdio.h>
#include <string.h>

void begin_critical_section(void);
void end_critical_section(void);

FILE *getFilePointer(void);
```

```
void func(FILE *fp) {
  fpos_t pos;
  errno = 0;
  if (0 != fgetpos(fp, &pos)) {
    char *errmsg = strerror(errno);
    printf("Could not get the file position: %s\n", errmsg);
  }
}

void task1(void) {
    FILE* fptr1 = getFilePointer();
    func(fptr1);
}

void task2(void) {
     FILE* fptr2 = getFilePointer();
     func(fptr2);
}

void task3(void) {
     FILE* fptr3 = getFilePointer();
     begin_critical_section();
     func(fptr3);
     end_critical_section();
}
```

In this example, to emulate multitasking behavior, specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	task1 task2 task3	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section	end_critical_section

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
  -entry-points task1,task2,task3
  -critical-section-begin begin_critical_section:cs1
  -critical-section-end end_critical_section:cs1
```

In this example, the tasks, `task1`, `task2` and `task3`, call the function `func`. `func` calls the nonreentrant standard library function, `strerror`.

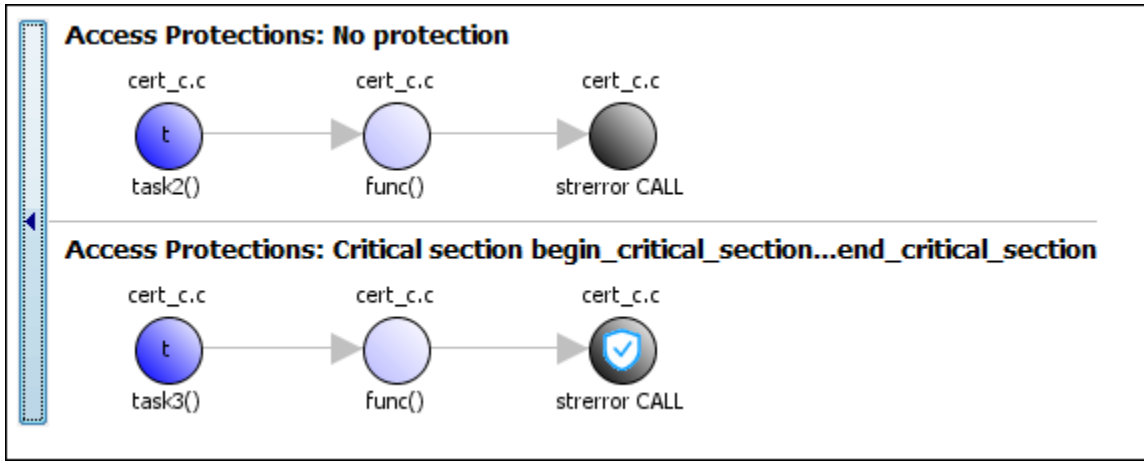
Though `task3` calls `func` inside a critical section, other tasks do not use the same critical section. Operations in the critical section of `task3` are not mutually exclusive with operations in other tasks.

These three tasks are calling a nonreentrant standard library function without common protection. In your result details, you see each pair of conflicting function calls.

! Data race through standard library function call (Impact: High)
Certain calls to function 'strerror' can interfere with each other and cause unpredictable results.
To avoid interference, calls to 'strerror' must be in the same critical section.

	Access	Access Protections	Task	File	Scope	Line
	Function call (Non atomic) Operation involves function call	No protection	task1()	data_race_std_lib.c	func()	14
	Function call (Non atomic) Operation involves function call	No protection	task2()	data_race_std_lib.c	func()	14
	Function call (Non atomic) Operation involves function call	No protection	task2()	data_race_std_lib.c	func()	14
	Function call (Non atomic) Operation involves function call	**Critical section begin_critical_section...end_critical_section**	task3()	data_race_std_lib.c	func()	14
	Function call (Non atomic) Operation involves function call	No protection	task1()	data_race_std_lib.c	func()	14
	Function call (Non atomic) Operation involves function call	**Critical section begin_critical_section...end_critical_section**	task3()	data_race_std_lib.c	func()	14

If you click the  icon, you see the function call sequence starting from the entry point to the standard library function call. You also see that the call starting from `task3` is in a critical section. The **Access Protections** entry shows the lock and unlock function that begin and end the critical section. In this example, you see the functions `begin_critical_section` and `end_critical_section`.



Correction — Use Reentrant Version of Standard Library Function

One possible correction is to use a reentrant version of the standard library function `strerror`. You can use the POSIX version `strerror_r` which has the same functionality but also guarantees thread-safety.

```
#include <errno.h>
#include <stdio.h>
#include <string.h>

void begin_critical_section(void);
void end_critical_section(void);

FILE *getFilePointer(void);
enum { BUFFERSIZE = 64 };

void func(FILE *fp) {
  fpos_t pos;
  errno = 0;
  if (0 != fgetpos(fp, &pos)) {
    char errmsg[BUFFERSIZE];
    if (strerror_r(errno, errmsg, BUFFERSIZE) != 0) {
      /* Handle error */
    }
    printf("Could not get the file position: %s\n", errmsg);
  }
```

```
}

void task1(void) {
    FILE* fptr1 = getFilePointer();
    func(fptr1);
}

void task2(void) {
     FILE* fptr2 = getFilePointer();
     func(fptr2);
}

void task3(void) {
     FILE* fptr3 = getFilePointer();
     begin_critical_section();
     func(fptr3);
     end_critical_section();
}
```

Correction — Place Function Call in Critical Section

One possible correction is to place the call to `strerror` in critical section. You can implement the critical section in multiple ways.

For instance, you can place the call to the intermediate function `func` in the same critical section in the three tasks. When `task1` enters its critical section, the other tasks cannot enter their critical sections until `task1` leaves its critical section. The calls to `func` and therefore the calls to `strerror` from the three tasks cannot interfere with each other.

To implement the critical section, in each of the three tasks, call `func` between calls to `begin_critical_section` and `end_critical_section`.

```
#include <errno.h>
#include <stdio.h>
#include <string.h>

void begin_critical_section(void);
void end_critical_section(void);

FILE *getFilePointer(void);

void func(FILE *fp) {
  fpos_t pos;
```

```
  errno = 0;
  if (0 != fgetpos(fp, &pos)) {
    char *errmsg = strerror(errno);
    printf("Could not get the file position: %s\n", errmsg);
  }
}

void task1(void) {
    FILE* fptr1 = getFilePointer();
    begin_critical_section();
    func(fptr1);
    end_critical_section();
}

void task2(void) {
     FILE* fptr2 = getFilePointer();
     begin_critical_section();
     func(fptr2);
     end_critical_section();
}

void task3(void) {
     FILE* fptr3 = getFilePointer();
     begin_critical_section();
     func(fptr3);
     end_critical_section();
}
```

Correction — Make Tasks Temporally Exclusive

Another possible correction is to make the tasks, `task1`, `task2` and `task3`, temporally exclusive. Temporally exclusive tasks cannot execute concurrently.

On the **Configuration** pane, specify the following additional options:

Option	Value
`Temporally exclusive tasks (-temporal-exclusions-file)`	`task1 task2 task3`

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
    -temporal-exclusions-file "C:\exclusions_file.txt"
```

where the file `C:\exclusions_file.txt` has the following line:

```
task1 task2 task3
```

Check Information

Group: Rule 14. Concurrency (CON)

See Also

External Websites

CON33-C

Introduced in R2019a

CERT C: Rule CON35-C

Avoid deadlock by locking in a predefined order

Description

Rule Definition

Avoid deadlock by locking in a predefined order.

Examples

Deadlock

Description

Deadlock occurs when multiple tasks are stuck in their critical sections (CS) because:

- Each CS waits for another CS to end.
- The critical sections (CS) form a closed cycle. For example:
  - CS #1 waits for CS #2 to end, and CS #2 waits for CS #1 to end.
  - CS #1 waits for CS #2 to end, CS #2 waits for CS #3 to end and CS #3 waits for CS #1 to end.

Polyspace expects critical sections of code to follow a specific format. A critical section lies between a call to a lock function and a call to an unlock function. When a task `my_task` calls a lock function `my_lock`, other tasks calling `my_lock` must wait until `my_task` calls the corresponding unlock function. Both lock and unlock functions must have the form `void func(void)`.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**.

Risk

Each task waits for a critical section in another task to end and is unable to proceed. The program can freeze indefinitely.

Fix

The fix depends on the root cause of the defect. You can try to break the cyclic order between the tasks in one of these ways:

- Write down all critical sections involved in the deadlock in a certain sequence. Whenever you call the lock functions of the critical sections within a task, respect the order in that sequence. See an example below.
- If one of the critical sections involved in a deadlock occurs in an interrupt, try to disable all interrupts during critical sections in all tasks. See `Disabling all interrupts (-routine-disable-interrupts -routine-enable-interrupts)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Reviewing this defect is an opportunity to check if all operations in your critical section are really meant to be executed as an atomic block. It is a good practice to keep critical sections at a bare minimum.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Deadlock with Two Tasks

```
void task1(void);
void task2(void);

int var;
void perform_task_cycle(void) {
 var++;
}

void begin_critical_section_1(void);
void end_critical_section_1(void);

void begin_critical_section_2(void);
```

```
void end_critical_section_2(void);

void task1() {
 while(1) {
    begin_critical_section_1();
    begin_critical_section_2();
    perform_task_cycle();
    end_critical_section_2();
    end_critical_section_1();
 }
}

void task2() {
 while(1) {
    begin_critical_section_2();
    begin_critical_section_1();
    perform_task_cycle();
    end_critical_section_1();
    end_critical_section_2();
 }
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	**Specification**	
Configure multitasking manually	☑	

Entry points	`task1`
	
	`task2`	

Critical section details	**Starting routine**	**Ending routine**
	`begin_critical_section_1`	`end_critical_section_1`
	`begin_critical_section_2`	`end_critical_section_2`

A **Deadlock** occurs because the instructions can execute in the following sequence:

1. `task1` calls `begin_critical_section_1`.
2. `task2` calls `begin_critical_section_2`.

3. `task1` reaches the instruction `begin_critical_section_2();`. Since `task2` has already called `begin_critical_section_2`, `task1` waits for `task2` to call `end_critical_section_2`.
4. `task2` reaches the instruction `begin_critical_section_1();`. Since `task1` has already called `begin_critical_section_1`, `task2` waits for `task1` to call `end_critical_section_1`.

Correction-Follow Same Locking Sequence in Both Tasks

One possible correction is to follow the same sequence of calls to lock and unlock functions in both `task1` and `task2`.

```
void task1(void);
void task2(void);
void perform_task_cycle(void);

void begin_critical_section_1(void);
void end_critical_section_1(void);

void begin_critical_section_2(void);
void end_critical_section_2(void);

void task1() {
 while(1) {
    begin_critical_section_1();
    begin_critical_section_2();
    perform_task_cycle();
    end_critical_section_2();
    end_critical_section_1();
 }
}

void task2() {
 while(1) {
    begin_critical_section_1();
    begin_critical_section_2();
    perform_task_cycle();
    end_critical_section_2();
    end_critical_section_1();
 }
}
```

Example - Deadlock with More Than Two Tasks

```
int var;
void performTaskCycle() {
 var++;
}

void lock1(void);
void lock2(void);
void lock3(void);


void unlock1(void);
void unlock2(void);
void unlock3(void);

void task1() {
 while(1) {
    lock1();
    lock2();
    performTaskCycle();
    unlock2();
    unlock1();
 }
}

void task2() {
 while(1) {
    lock2();
    lock3();
    performTaskCycle();
    unlock3();
    unlock2();
 }
}

void task3() {
 while(1) {
    lock3();
    lock1();
    performTaskCycle();
```

```
    unlock1();
    unlock3();
 }
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	Specification	
Configure multitasking manually	☑	

Entry points	`task1`
	`task2`
	`task3`	

Critical section details	**Starting routine**	**Ending routine**
	`lock1`	`unlock1`
	`lock2`	`unlock2`
	`lock3`	`unlock3`

A **Deadlock** occurs because the instructions can execute in the following sequence:

1. `task1` calls `lock1`.
2. `task2` calls `lock2`.
3. `task3` calls `lock3`.
4. `task1` reaches the instruction `lock2();`. Since `task2` has already called `lock2`, `task1` waits for call to `unlock2`.
5. `task2` reaches the instruction `lock3();`. Since `task3` has already called `lock3`, `task2` waits for call to `unlock3`.
6. `task3` reaches the instruction `lock1();`. Since `task1` has already called `lock1`, `task3` waits for call to `unlock1`.

Correction — Break Cyclic Order

To break the cyclic order between critical sections, note every lock function in your code in a certain sequence, for example:

1. `lock1`

2. `lock2`
3. `lock3`

If you use more than one lock function in a task, use them in the order in which they appear in the sequence. For example, you can use `lock1` followed by `lock2` but not `lock2` followed by `lock1`.

```
int var;
void performTaskCycle() {
 var++;
}

void lock1(void);
void lock2(void);
void lock3(void);

void unlock1(void);
void unlock2(void);
void unlock3(void);

void task1() {
 while(1) {
    lock1();
    lock2();
    performTaskCycle();
    unlock2();
    unlock1();
 }
}

void task2() {
 while(1) {
    lock2();
    lock3();
    performTaskCycle();
    unlock3();
    unlock2();
 }
}

void task3() {
```

```
 while(1) {
    lock1();
    lock3();
    performTaskCycle();
    unlock3();
    unlock1();
 }
}
```

Check Information

Group: Rule 14. Concurrency (CON)

See Also

External Websites

CON35-C

Introduced in R2019a

CERT C: Rule CON36-C

Wrap functions that can spuriously wake up in a loop

Description

Rule Definition

Wrap functions that can spuriously wake up in a loop.

Examples

Function that can spuriously wake up not wrapped in loop

Description

Function that can spuriously wake up not wrapped in loop occurs when the following wait-on-condition functions are called from outside a loop:

- C functions:
  - `cnd_wait()`
  - `cnd_timedwait()`
- POSIX functions:
  - `pthread_cond_wait()`
  - `pthread_cond_timedwait()`
- C++ `std::condition_variable` and `std::condition_variable_any` class member functions:
  - `wait()`
  - `wait_until()`
  - `wait_for()`

Wait-on-condition functions pause the execution of the calling thread when a specified condition is met. The thread wakes up and resumes once another thread notifies it with `cnd_broadcast()` or an equivalent function. The wake-up notification can be spurious or malicious.

Risk

If a thread receives a spurious wake-up notification and the condition of the wait-on-condition function is not checked, the thread can wake up prematurely. The wake-up can cause unexpected control flow, indefinite blocking of other threads, or denial of service.

Fix

Wrap wait-on-condition functions that can wake up spuriously in a loop. The loop checks the wake-up condition after a possible spurious wake-up notification.

Example - `cnd_wait()` Not Wrapped in Loop

```
#include <stdio.h>
#include <stddef.h>
#include <threads.h>

#define THRESHOLD 100

static mtx_t lock;
static cnd_t cond;

void func(int input)
{
    if (thrd_success != mtx_lock(&lock)) {
        /* Handle error */
    }
    /* test condition to pause thread */
    if (input > THRESHOLD) {
        if (thrd_success != cnd_wait(&cond, &lock)) {
            /* Handle error */
        }
    }
    /* Proceed if condition to pause does not hold */


    if (thrd_success != mtx_unlock(&lock)) {
        /* Handle error */
    }
```

```
}
```

In this example, the thread uses `cnd_wait()` to pause execution when `input` is greater than `THRESHOLD`. The paused thread can resume if another thread uses `cnd_broadcast()`, which notifies all the threads. This notification causes the thread to wake up even if the pause condition is still true.

Correction — Wrap `cnd_wait()` in a `while` Loop

One possible correction is to wrap `cnd_wait()` in a `while` loop. The loop checks the pause condition after the thread receives a possible spurious wake-up notification.

```
#include <stdio.h>
#include <stddef.h>
#include <threads.h>

#define THRESHOLD 100

static mtx_t lock;
static cnd_t cond;

void func(int input)
{
    if (thrd_success != mtx_lock(&lock)) {
        /* Handle error */
    }
    /* test condition to pause thread */
    while (input > THRESHOLD) {
        if (thrd_success != cnd_wait(&cond, &lock)) {
            /* Handle error */
        }
    }
    /* Proceed if condition to pause does not hold */


    if (thrd_success != mtx_unlock(&lock)) {
        /* Handle error */
    }
}
```

Check Information

Group: Rule 14. Concurrency (CON)

See Also

External Websites

CON36-C

Introduced in R2019a

CERT C: Rule CON37-C

Do not call signal() in a multithreaded program

Description

Rule Definition

Do not call signal() in a multithreaded program.

Examples

Signal call in multithreaded program

Description

Signal call in multithreaded program occurs when you use the `signal()` function in a program with multiple threads.

Risk

According to the C11 standard (Section 7.14.1.1), use of the `signal()` function in a multithreaded program is undefined behavior.

Fix

Depending on your intent, use other ways to perform an asynchronous action on a specific thread.

Example - Use of `signal()` Function to Terminate Loop in Thread

```
#include <signal.h>
#include <stddef.h>
#include <threads.h>

volatile sig_atomic_t flag = 0;
```

```
void handler(int signum) {
  flag = 1;
}

/* Runs until user sends SIGUSR1 */
int func(void *data) {
  while (!flag) {
    /* ... */
  }
  return 0;
}

int main(void) {
  signal(SIGINT, handler); /* Undefined behavior */
  thrd_t tid;

  if (thrd_success != thrd_create(&tid, func, NULL)) {
    /* Handle error */
  }
  /* ... */
  return 0;
}
```

In this example, the `signal` function is used to terminate a `while` loop in the thread created with `thrd_create`.

Correction — Use `atomic_bool` Variable to Terminate Loop

One possible correction is to use an `atomic_bool` variable that multiple threads can access. In the corrected example, the child thread evaluates this variable before every loop iteration. After completing the program, you can modify this variable so that the child thread exits the loop.

```
#include <stdatomic.h>
#include <stdbool.h>
#include <stddef.h>
#include <threads.h>

atomic_bool flag = ATOMIC_VAR_INIT(false);

int func(void *data) {
  while (!flag) {
    /* ... */
```

```
  }
  return 0;
}

int main(void) {
  thrd_t tid;

  if (thrd_success != thrd_create(&tid, func, NULL)) {
    /* Handle error */
  }
  /* ... */
  /* Set flag when done */
  flag = true;

  return 0;
}
```

Check Information

Group: Rule 14. Concurrency (CON)

See Also

External Websites

CON37-C

Introduced in R2019a

CERT C: Rule CON40-C

Do not refer to an atomic variable twice in an expression

Description

Rule Definition

Do not refer to an atomic variable twice in an expression.

Examples

Atomic variable accessed twice in an expression

Description

Atomic variable accessed twice in an expression occurs when C atomic types or C++ `std::atomic` class variables appear twice in an expression and there are:

- Two atomic read operations on the variable.
- An atomic read and a distinct atomic write operation on the variable.

The C standard defines certain operations on atomic variables that are thread safe and do not cause data race conditions. Unlike individual operations, a pair of operations on the same atomic variable in an expression is not thread safe.

Risk

A thread can modify the atomic variable between the pair of atomic operations, which can result in a data race condition.

Fix

Do not reference an atomic variable twice in the same expression.

Example - Referencing Atomic Variable Twice in an Expression

```
#include <stdatomic.h>

atomic_int n = ATOMIC_VAR_INIT(0);

int compute_sum(void)
{
    return n * (n + 1) / 2;
}
```

In this example, the global variable `n` is referenced twice in the return statement of `compute_sum()`. The value of `n` can change between the two distinct read operations. `compute_sum()` can return an incorrect value.

Correction — Pass Variable as Function Argument

One possible correction is to pass the variable as a function argument `n`. The variable is copied to memory and the read operations on the copy guarantee that `compute_sum()` returns a correct result. If you pass a variable of type `int` instead of type `atomic_int`, the correction is still valid.

```
#include <stdatomic.h>

int compute_sum(atomic_int n)
{
    return n * (n + 1) / 2;
}
```

Atomic load and store sequence not atomic

Description

Atomic load and store sequence not atomic occurs when you use these functions to load, and then store an atomic variable.

- C functions:
  - `atomic_load()`
  - `atomic_load_explicit()`
  - `atomic_store()`

  - `atomic_store_explicit()`
- C++ functions:
  - `std::atomic_load()`
  - `std::atomic_load_explicit()`
  - `std::atomic_store()`
  - `std::atomic_store_explicit()`
  - `std::atomic::load()`
  - `std::atomic::store()`

A thread cannot interrupt an atomic load or an atomic store operation on a variable, but a thread can interrupt a store, and then load sequence.

Risk

A thread can modify a variable between the load and store operations, resulting in a data race condition.

Fix

To read, modify, and store a variable atomically, use a compound assignment operator such as `+=`, `atomic_compare_exchange()` or `atomic_fetch_*`-family functions.

Example - Loading Then Storing an Atomic Variable

```
#include <stdatomic.h>
#include <stdbool.h>

static atomic_bool flag = ATOMIC_VAR_INIT(false);

void init_flag(void)
{
    atomic_init(&flag, false);
}

void toggle_flag(void)
{
    bool temp_flag = atomic_load(&flag);
    temp_flag = !temp_flag;
    atomic_store(&flag, temp_flag);
}
```

```
bool get_flag(void)
{
    return atomic_load(&flag);
}
```

In this example, variable `flag` of type `atomic_bool` is referenced twice inside the `toggle_flag()` function. The function loads the variable, negates its value, then stores the new value back to the variable. If two threads call `toggle_flag()`, the second thread can access `flag` between the load and store operations of the first thread. `flag` can end up in an incorrect state.

Correction — Use Compound Assignment to Modify Variable

One possible correction is to use a compound assignment operator to toggle the value of `flag`. The C standard defines the operation by using ^= as atomic.

```
 #include <stdatomic.h>
#include <stdbool.h>

static atomic_bool flag = ATOMIC_VAR_INIT(false);

void toggle_flag(void)
{
    flag ^= 1;
}

bool get_flag(void)
{
    return flag;
}
```

Check Information

Group: Rule 14. Concurrency (CON)

See Also

External Websites

CON40-C

Introduced in R2019a

CERT C: Rule CON41-C

Wrap functions that can fail spuriously in a loop

Description

Rule Definition

Wrap functions that can fail spuriously in a loop.

Examples

Function that can spuriously fail not wrapped in loop

Description

Function that can spuriously fail not wrapped in loop occurs when the following atomic compare and exchange functions that can fail spuriously are called from outside a loop.

- C atomic functions:
  - `atomic_compare_exchange_weak()`
  - `atomic_compare_exchange_weak_explicit()`
- C++ atomic functions:
  - `std::atomic<T>::compare_exchange_weak(T* expected, T desired)`
  - `std::atomic<T>::compare_exchange_weak_explicit(T* expected, T desired, std::memory_order succ, std::memory_order fail)`
  - `std::atomic_compare_exchange_weak(std::atomic<T>* obj, T* expected, T desired)`
  - `std::atomic_compare_exchange_weak_explicit(volatile std::atomic<T>* obj, T* expected, T desired, std::memory_order succ, std::memory_order fail)`

The functions compare the memory contents of the object representations pointed to by `obj` and `expected`. The comparison can spuriously return false even if the memory contents are equal. This spurious failure makes the functions faster on some platforms.

Risk

An atomic compare and exchange function that spuriously fails can cause unexpected results and unexpected control flow.

Fix

Wrap atomic compare and exchange functions that can spuriously fail in a loop. The loop checks the failure condition after a possible spurious failure.

Example - `atomic_compare_exchange_weak()` Not Wrapped in Loop

```
#include <stdatomic.h>

extern void reset_count(void);
atomic_int count = ATOMIC_VAR_INIT(0);

void increment_count(void)
{
    int old_count = atomic_load(&count);
    int new_count;
    new_count = old_count + 1;
    if (!atomic_compare_exchange_weak(&count, &old_count, new_count))
        reset_count();

}
```

In this example, `increment_count()` uses `atomic_compare_exchange_weak()` to compare `count` and `old_count`. If the counts are equal, `count` is incremented to `new_count`. If they are not equal, the count is reset. When `atomic_compare_exchange_weak()` fails spuriously, the count is reset unnecessarily.

Correction — Wrap `atomic_compare_exchange_weak()` in a `while` Loop

One possible correction is to wrap the call to `atomic_compare_exchange_weak()` in a `while` loop. The loop checks the failure condition after a possible spurious failure.

```
#include <stdatomic.h>

extern void reset_count(void);
```

```
atomic_int count = ATOMIC_VAR_INIT(0);

void increment_count(void)
{
    int old_count = atomic_load(&count);
    int new_count;
    new_count = old_count + 1;

    do {
        reset_count();

    } while (!atomic_compare_exchange_weak(&count, &old_count, new_count));

}
```

Check Information

Group: Rule 14. Concurrency (CON)

See Also

External Websites

CON41-C

Introduced in R2019a

CERT C: Rule CON43-C

Do not allow data races in multithreaded code

Description

Rule Definition

Do not allow data races in multithreaded code.

Examples

Data race

Description

Data race occurs when:

1. Multiple tasks perform unprotected operations on a shared variable.
2. At least one task performs a write operation.
3. At least one operation is nonatomic. For data race on both atomic and nonatomic operations, see `Data race including atomic operations`.

   See also the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server..

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**. For more information, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server..

Risk

Data race can result in unpredictable values of the shared variable because you do not control the order of the operations in different tasks.

Data races between two write operations are more serious than data races between a write and read operation. Two write operations can interfere with each other and result in indeterminate values. To identify write-write conflicts, use the filters on the **Detail** column of the **Results List** pane. For these conflicts, the **Detail** column shows the additional line:

```
Variable value may be altered by write-write concurrent access.
```

See “Filter and Sort Results”.

Fix

To fix this defect, protect the operations on the shared variable using critical sections, temporal exclusion or another means. See the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server..

To identify existing protections that you can reuse, see the table and graphs associated with the result. The table shows each pair of conflicting calls. The **Access Protections** column shows existing protections on the calls. To see the function call sequence leading to the conflicts, click the  icon. For an example, see below.

Example - Unprotected Operation on Global Variable from Multiple Tasks

```
int var;
void begin_critical_section(void);
void end_critical_section(void);

void increment(void) {
    var++;
}

void task1(void)  {
      increment();
}

void task2(void)  {
      increment();
}

void task3(void)  {
```

```
     begin_critical_section();
     increment();
     end_critical_section();
}
```

In this example, to emulate multitasking behavior, specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	task1 task2 task3	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section	end_critical_section

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
   -entry-points task1,task2,task3
   -critical-section-begin begin_critical_section:cs1
   -critical-section-end end_critical_section:cs1
```

In this example, the tasks `task1`, `task2`, and `task3` call the function `increment`. `increment` contains the operation `var++` that can involve multiple machine instructions including:

- Reading `var`.
- Writing an increased value to `var`.

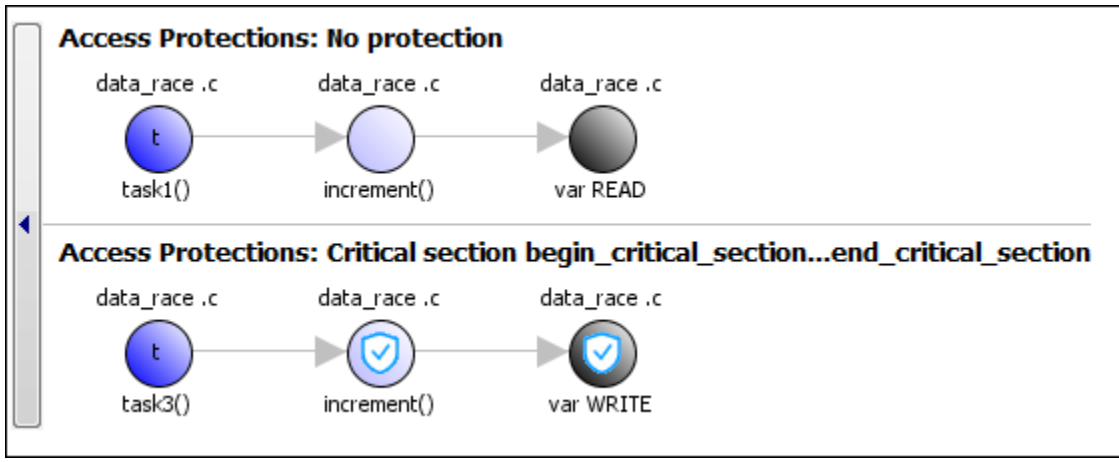
These machine instructions, when executed from `task1` and `task2`, can occur concurrently in an unpredictable sequence. For example, reading `var` from `task1` can occur either before or after writing to `var` from `task2`. Therefore the value of `var` can be unpredictable.

Though `task3` calls `increment` inside a critical section, other tasks do not use the same critical section. The operations in the critical section of `task3` are not mutually exclusive with operations in other tasks.

Therefore, the three tasks are operating on a shared variable without common protection. In your result details, you see each pair of conflicting function calls.

	Access	Access Protections	Task	File
	Read	No protection	task1()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	No protection	task2()	data_race .c
	Read	No protection	task1()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	**Critical section begin_critical_section...end_critical_section**	task3()	data_race .c
	Read	No protection	task2()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	**Critical section begin_critical_section...end_critical_section**	task3()	data_race .c

If you click the  icon, you see the function call sequence starting from the entry point to the read or write operation. You also see that the operation starting from `task3` is in a critical section. The **Access Protections** entry shows the lock and unlock function that begin and end the critical section. In this example, you see the functions `begin_critical_section` and `end_critical_section`.



Correction — Place Operation in Critical Section

One possible correction is to place the operation in critical section. You can implement the critical section in multiple ways. For instance:

- You can place `var++` in a critical section. When `task1` enters its critical section, the other tasks cannot enter their critical sections until `task1` leaves its critical section. The operation `var++` from the three tasks cannot interfere with each other.

  To implement the critical section, in the function `increment`, place the operation `var ++` between calls to `begin_critical_section` and `end_critical_section`.

  ```
  int var;

  void begin_critical_section(void);
  void end_critical_section(void);

  void increment(void) {
        begin_critical_section();
        var++;
        end_critical_section();
  }

  void task1(void)  {
        increment();
  }

  void task2(void)  {
        increment();
  }

  void task3(void)  {
        increment();
  }
  ```

- You can place the call to `increment` in the same critical section in the three tasks. When `task1` enters its critical section, the other tasks cannot enter their critical sections until `task1` leaves its critical section. The calls to `increment` from the three tasks cannot interfere with each other.

  To implement the critical section, in each of the three tasks, call `increment` between calls to `begin_critical_section` and `end_critical_section`.

```
int var;

void begin_critical_section(void);
void end_critical_section(void);

void increment(void) {
      var++;
}

void task1(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}

void task2(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}

void task3(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}
```

Correction — Make Tasks Temporally Exclusive

Another possible correction is to make the tasks, `task1`, `task2` and `task3`, temporally exclusive. Temporally exclusive tasks cannot execute concurrently.

On the **Configuration** pane, specify the following additional options:

Option	Value
`Temporally exclusive tasks (-temporal-exclusions-file)`	`task1 task2 task3`

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
 polyspace-bug-finder
     -temporal-exclusions-file "C:\exclusions_file.txt"
```

where the file `C:\exclusions_file.txt` has the following line:

```
task1 task2 task3
```

Example - Unprotected Operation in Threads Created with `pthread_create`

```
#include <pthread.h>

pthread_mutex_t count_mutex;
long long count;


void* increment_count(void* args)
{
    count = count + 1;
    return NULL;
}

void* set_count(void *args)
{
    long long c;
    c = count;
    return NULL;
}

int main(void)
{
    pthread_t thread_increment;
    pthread_t thread_get;

    pthread_create(&thread_increment, NULL, increment_count, NULL);
    pthread_create(&thread_get, NULL, set_count, NULL);

    pthread_join(thread_get, NULL);
    pthread_join(thread_increment, NULL);

    return 1;
}
```

In this example, Bug Finder detects the creation of separate threads with `pthread_create`. The **Data race** defect is raised because the operation `count = count + 1` in the thread with id `thread_increment` conflicts with the operation `c = count` in the thread with id `thread_get`. The variable `count` is accessed in multiple threads without a common protection.

The two conflicting operations are nonatomic. The operation `c = count` is nonatomic on 32-bit targets. See the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server..

Correction — Protect Operations with `pthread_mutex_lock` and `pthread_mutex_unlock` Pair

To prevent concurrent access on the variable `count`, protect operations on `count` with a critical section. Use the functions `pthread_mutex_lock` and `pthread_mutex_unlock` to implement the critical section.

```
#include <pthread.h>

pthread_mutex_t count_mutex;
long long count;


void* increment_count(void* args)
{
    pthread_mutex_lock(&count_mutex);
    count = count + 1;
    pthread_mutex_unlock(&count_mutex);
    return NULL;
}

void* set_count(void *args)
{
    long long c;
    pthread_mutex_lock(&count_mutex);
    c = count;
    pthread_mutex_unlock(&count_mutex);
    return NULL;
}

int main(void)
{
    pthread_t thread_increment;
    pthread_t thread_get;
```

```
    pthread_create(&thread_increment, NULL, increment_count, NULL);
    pthread_create(&thread_get, NULL, set_count, NULL);

    pthread_join(thread_get, NULL);
    pthread_join(thread_increment, NULL);

    return 1;
}
```

Check Information

Group: Rule 14. Concurrency (CON)

See Also

External Websites

CON43-C

Introduced in R2019a

Rule 48. Miscellaneous (MSC)

CERT C: Rule MSC30-C

Do not use the rand() function for generating pseudorandom numbers

Description

Rule Definition

Do not use the rand() function for generating pseudorandom numbers.

Examples

Vulnerable pseudo-random number generator

Description

The **Vulnerable pseudo-random number generator** identifies uses of cryptographically weak pseudo-random number generator (PRNG) routines.

The list of cryptographically weak routines flagged by this checker include:

- `rand`, `random`
- `drand48`, `lrand48`, `mrand48`, `erand48`, `nrand48`, `jrand48`, and their `_r` equivalents such as `drand48_r`
- `RAND_pseudo_bytes`

Risk

These cryptographically weak routines are predictable and must not be used for security purposes. When a predictable random value controls the execution flow, your program is vulnerable to malicious attacks.

Fix

Use more cryptographically sound random number generators, such as `CryptGenRandom` (Windows), `OpenSSL/RAND_bytes`(Linux/UNIX).

Example - Random Loop Numbers

```
#include <stdio.h>
#include <stdlib.h>

volatile int rd = 1;
int main(int argc, char *argv[])
{
    int j, r, nloops;
    struct random_data buf;
    int i = 0;

    nloops = rand();

    for (j = 0; j < nloops; j++) {
        if (random_r(&buf, &i))
            exit(1);
        printf("random_r: %ld\n", (long)i);
    }
    return 0;
}
```

This example uses `rand` and `random_r` to generate random numbers. If you use these functions for security purposes, these PRNGs can be the source of malicious attacks.

Correction — Use Stronger PRNG

One possible correction is to replace the vulnerable PRNG with a stronger random number generator.

```
#include <stdio.h>
#include <stdlib.h>
#include <openssl/rand.h>

volatile int rd = 1;
int main(int argc, char* argv[])
{
    int j, r, nloops;
    unsigned char buf;
    unsigned int seed;
    int i = 0;

    if (argc != 3)
```

```
    {
        fprintf(stderr, "Usage: %s <seed> <nloops>\n", argv[0]);
        exit(EXIT_FAILURE);
    }

    seed = atoi(argv[1]);
    nloops = atoi(argv[2]);

    for (j = 0; j < nloops; j++) {
        if (RAND_bytes(&buf, i) != 1)
            exit(1);
        printf("RAND_bytes: %u\n", (unsigned)buf);
    }
    return 0;
}
```

Check Information

Group: Rule 48. Miscellaneous (MSC)

See Also

External Websites

MSC30-C

Introduced in R2019a

CERT C: Rule MSC32-C

Properly seed pseudorandom number generators

Description

Rule Definition

Properly seed pseudorandom number generators.

Examples

Deterministic random output from constant seed

Description

Deterministic random output from constant seed detects random standard functions that when given a constant seed, have deterministic output.

Risk

When some random functions, such as `srand`, `srandom`, and `initstate`, have constant seeds, the results produce the same output every time that your program is run. A hacker can disrupt your program if they know how your program behaves.

Fix

Use a different random standard function or use a nonconstant seed.

Some standard random routines are inherently cryptographically weak on page 1-885, and should not be used for security purposes.

Example - Random Number Generator Initialization

```
#include <stdlib.h>
```

```
void random_num(void)
{
    srand(12345U);
    /* ... */
}
```

This example initializes a random number generator using `srand` with a constant seed. The random number generation is deterministic, making this function cryptographically weak.

Correction — Use Different Random Number Generator

One possible correction is to use a random number generator that does not require a seed. This example uses `rand_s`.

```
#define _CRT_RAND_S
#include <stdlib.h>
#include <stdio.h>

unsigned int random_num_time(void)
{

    unsigned int number;
    errno_t err;
    err = rand_s(&number);

    if(err != 0)
    {
        return number;
    }
    else
    {
        return err;
    }
}
```

Predictable random output from predictable seed

Description

Predictable random output from predictable seed looks for random standard functions that use a nonconstant but predictable seed. Examples of predictable seed generators are `time`, `gettimeofday`, and `getpid`.

Risk

When you use predictable seed values for random number generation, your random numbers are also predictable. A hacker can disrupt your program if they know how your program behaves.

Fix

You can use a different function to generate less predictable seeds.

You can also use a different random number generator that does not require a seed. For example, the Windows API function `rand_s` seeds itself by default. It uses information from the entire system, for example, system time, thread ids, system counter, and memory clusters. This information is more random and a user cannot access this information.

Some standard random routines are inherently cryptographically weak on page 1-885, and should not be used for security purposes.

Example - Seed as an Argument

```
#include <stdlib.h>
#include <time.h>

void seed_rng(int seed)
{
    srand(seed);
}

int generate_num(void)
{
    seed_rng(time(NULL) + 3);
    /* ... */
}
```

This example uses `srand` to start the random number generator with `seed` as the seed. However, `seed` is predictable because the function `time` generates it. So, an attacker can predict the random numbers generated by `srand`.

Correction — Use Different Random Number Generator

One possible correction is to use a random number generator that does not require a seed. This example uses `rand_s`.

```
#define _CRT_RAND_S

#include <stdlib.h>
#include <stdio.h>
#include <errno.h>

int generate_num(void)
{
    unsigned int number;
    errno_t err;
    err = rand_s(&number);

    if(err != 0)
    {
        return number;
    }
    else
    {
        return err;
    }
}
```

Check Information

Group: Rule 48. Miscellaneous (MSC)

See Also

External Websites

MSC32-C

Introduced in R2019a

CERT C: Rule MSC33-C

Do not pass invalid data to the asctime() function

Description

Rule Definition

Do not pass invalid data to the asctime() function.

Examples

Use of obsolete standard function

Description

Use of obsolete standard function detects calls to standard function routines that are considered legacy, removed, deprecated, or obsolete by C/C++ coding standards.

Obsolete Function	Standards	Risk	Replacement Function
`asctime`	Deprecated in POSIX.1-2008	Not thread-safe.	`strftime` or `asctime_s`
`asctime_r`	Deprecated in POSIX.1-2008	Implementation based on unsafe function `sprintf`.	`strftime` or `asctime_s`
`bcmp`	Deprecated in 4.3BSD Marked as legacy in POSIX.1-2001.	Returns from function after finding the first differing byte, making it vulnerable to timing attacks.	`memcmp`

Obsolete Function	Standards	Risk	Replacement Function
`bcopy`	Deprecated in 4.3BSD Marked as legacy in POSIX.1-2001.	Returns from function after finding the first differing byte, making it vulnerable to timing attacks.	`memcpy` or `memmove`
`brk` and `sbrk`	Marked as legacy in SUSv2 and POSIX.1-2001.		`malloc`
`bsd_signal`	Removed in POSIX.1-2008		`sigaction`
`bzero`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`memset`
`ctime`	Deprecated in POSIX.1-2008	Not thread-safe.	`strftime` or `asctime_s`
`ctime_r`	Deprecated in POSIX.1-2008	Implementation based on unsafe function `sprintf`.	`strftime` or `asctime_s`
`cuserid`	Removed in POSIX.1-2001.	Not reentrant. Precise functionality not standardized causing portability issues.	`getpwuid`
`ecvt` and `fcvt`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008	Not reentrant	`snprintf`
`ecvt_r` and `fcvt_r`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008		`snprintf`
`ftime`	Removed in POSIX.1-2008		`time`, `gettimeofday`, `clock_gettime`
`gamma`, `gammaf`, `gammal`	Function not specified in any standard because of historical variations	Portability issues.	`tgamma`, `lgamma`

Obsolete Function	Standards	Risk	Replacement Function
`gcvt`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`snprintf`
`getcontext`	Removed in POSIX.1-2008.	Portability issues.	Use POSIX thread instead.
`getdtablesize`	BSD API function not included in POSIX.1-2001	Portability issues.	`sysconf( _SC_OPEN_MAX )`
`gethostbyaddr`	Removed in POSIX.1-2008	Not reentrant	`getaddrinfo`
`gethostbyname`	Removed in POSIX.1-2008	Not reentrant	`getnameinfo`
`getpagesize`	BSD API function not included in POSIX.1-2001	Portability issues.	`sysconf( _SC_PAGESIZE )`
`getpass`	Removed in POSIX.1-2001.	Not reentrant.	`getpwuid`
`getw`	Not present in POSIX.1-2001.		`fread`
`getwd`	Marked legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`getcwd`
`index`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`strchr`
`makecontext`	Removed in POSIX.1-2008.	Portability issues.	Use POSIX thread instead.
`memalign`	Appears in SunOS 4.1.3. Not in 4.4 BSD or POSIX.1-2001		`posix_memalign`
`mktemp`	Removed in POSIX.1-2008.	Generated names are predictable and can cause a race condition.	`mkstemp` removes race risk
`pthread_attr_getstackaddr` and `pthread_attr_setstackaddr`		Ambiguities in the specification of the `stackaddr` attribute cause portability issues	`pthread_attr_getstack` and `pthread_attr_setstack`
`putw`	Not present in POSIX.1-2001.	Portability issues.	`fwrite`

Obsolete Function	Standards	Risk	Replacement Function
`qecvt` and `qfcvt`	Marked as legacy in POSIX.1-2001, removed in POSIX.1-2008		`snprintf`
`qecvt_r` and `qfcvt_r`	Marked as legacy in POSIX.1-2001, removed in POSIX.1-2008		`snprintf`
`rand_r`	Marked as obsolete in POSIX.1-2008		
`re_comp`	BSD API function	Portability issues	`regcomp`
`re_exes`	BSD API function	Portability issues	`regexec`
`rindex`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`strrchr`
`scalb`	Removed in POSIX.1-2008		`scalbln`, `scalblnf`, or `scalblnl`
`sigblock`	4.3BSD signal API whose origin is unclear		`sigprocmask`
`sigmask`	4.3BSD signal API whose origin is unclear		`sigprocmask`
`sigsetmask`	4.3BSD signal API whose origin is unclear		`sigprocmask`
`sigstack`	Interface is obsolete and not implemented on most platforms.	Portability issues.	`sigaltstack`
`sigvec`	4.3BSD signal API whose origin is unclear		`sigaction`
`swapcontext`	Removed in POSIX.1-2008	Portability issues.	Use POSIX threads.

Obsolete Function	Standards	Risk	Replacement Function
`tmpnam` and `tmpnam_r`	Marked as obsolete in POSIX.1-2008.	This function generates a different string each time it is called, up to TMP_MAX times. If it is called more than TMP_MAX times, the behavior is implementation-defined.	`mkstemp`, `tmpfile`
`ttyslot`	Removed in POSIX.1-2001.		
`ualarm`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.	Errors are under-specified	`setitimer` or POSIX `timer_create`
`usleep`	Removed in POSIX.1-2008.		`nanosleep`
`utime`	SVr4, POSIX.1-2001. POSIX.1-2008 marks as obsolete.		
`valloc`	Marked as obsolete in 4.3BSD. Marked as legacy in SUSv2. Removed from POSIX.1-2001		`posix_memalign`
`vfork`	Removed from POSIX.1-2008	Under-specified in previous standards.	`fork`
`wcswcs`	This function was not included in the final ISO/IEC 9899:1990/ Amendment 1:1995 (E).		`wcsstr`
`WinExec`	WinAPI provides this function only for 16-bit Windows compatibility.		`CreateProcess`
`LoadModule`	WinAPI provides this function only for 16-bit Windows compatibility.		`CreateProcess`

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Printing Out Time

```
#include <stdio.h>
#include <time.h>

void timecheck_bad(int argc, char *argv[])
{
    time_t ticks;

    ticks = time(NULL);
    printf("%.24s\r\n", ctime(&ticks));
}
```

In this example, the function `ctime` formats the current time and prints it out. However, `ctime` was removed after C99 because it does not work on multithreaded programs.

Correction — Different Time Function

One possible correction is to use `strftime` instead because this function uses a set buffer size.

```
#include <stdio.h>
#include <string.h>
#include <time.h>

void timecheck_good(int argc, char *argv[])
{
    char outBuff[1025];
    time_t ticks;
    struct tm * timeinfo;

    memset(outBuff, 0, sizeof(outBuff));
```

```
    ticks = time(NULL);
    timeinfo = localtime(&ticks);
    strftime(outBuff,sizeof(outBuff),"%I:%M%p.",timeinfo);
    fprintf(stdout, outBuff);
}
```

Check Information

Group: Rule 48. Miscellaneous (MSC)

See Also

External Websites

MSC33-C

Introduced in R2019a

CERT C: Rule MSC37-C

Ensure that control never reaches the end of a non-void function

Description

Rule Definition

Ensure that control never reaches the end of a non-void function.

Examples

Missing return statement

Description

Missing return statement occurs when a function does not return a value along at least one execution path. If the return type of the function is `void`, this error does not occur.

Risk

If a function has a non-`void` return value in its signature, it is expected to return a value. The return value of this function can be used in later computations. If the execution of the function body goes through a path where a `return` statement is missing, the function return value is indeterminate. Computations with this return value can lead to unpredictable results.

Fix

In most cases, you can fix this defect by placing the `return` statement at the end of the function body.

Alternatively, you can identify which execution paths through the function body do not have a `return` statement and add a `return` statement on those paths. Often the result details show a sequence of events that indicate this execution path. You can add a `return` statement at an appropriate point in the path. If the result details do not show

the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Missing or invalid return statement error

```
int AddSquares(int n)
 {
   int i=0;
   int sum=0;

   if(n!=0)
    {
     for(i=1;i<=n;i++)
        {
         sum+=i^2;
        }
     return(sum);
    }
 }
/* Defect: No return value if n is not 0*/
```

If `n` is equal to 0, the code does not enter the `if` statement. Therefore, the function `AddSquares` does not return a value if `n` is 0.

Correction — Place Return Statement on Every Execution Path

One possible correction is to return a value in every branch of the `if...else` statement.

```
 int AddSquares(int n)
 {
   int i=0;
   int sum=0;

   if(n!=0)
    {
     for(i=1;i<=n;i++)
        {
         sum+=i^2;
        }
```

```
    return(sum);
   }

  /*Fix: Place a return statement on branches of if-else */
  else
    return 0;
 }
```

Check Information

Group: Rule 48. Miscellaneous (MSC)

See Also

External Websites

MSC37-C

Introduced in R2019a

CERT C: Rule MSC38-C

Do not treat a predefined identifier as an object if it might only be implemented as a macro

Description

Rule Definition

Do not treat a predefined identifier as an object if it might only be implemented as a macro.

Examples

Predefined macro used as an object

Description

Predefined macro used as an object occurs when you use certain identifiers in a way that requires an underlying object to be present. These identifiers are defined as macros. The C Standard does not allow you to redefine them as objects. You use the identifiers in such a way that macro expansion of the identifiers cannot occur.

For instance, you refer to an external variable `errno`:

```
extern int errno;
```

However, `errno` does not occur as a variable but a macro.

The defect applies to these macros: `assert`, `errno`, `math_errhandling`, `setjmp`, `va_arg`, `va_copy`, `va_end`, and `va_start`. The checker looks for the defect only in source files (not header files).

Risk

The C11 Standard (Sec. 7.1.4) allows you to redefine most macros as objects. To access the object and not the macro in a source file, you do one of these:

- Redeclare the identifier as an external variable or function.
- For function-like macros, enclose the identifier name in parentheses.

If you try to use these strategies for macros that cannot be redefined as objects, an error occurs.

Fix

Do not use the identifiers in such a way that a macro expansion is suppressed.

- Do not redeclare the identifiers as external variables or functions.
- For function-like macros, do not enclose the macro name in parentheses.

Example - Use of `assert` as Function

```
#include<assert.h>
typedef void (*err_handler_func)(int);

extern void demo_handle_err(err_handler_func, int);

void func(int err_code) {
    extern void assert(int);
    demo_handle_err(&(assert), err_code);
}
```

In this example, the `assert` macro is redefined as an external function. When passed as an argument to `demo_handle_err`, the identifier `assert` is enclosed in parentheses, which suppresses use of the `assert` macro.

Correction — Use `assert` as Macro

One possible correction is to directly use the `assert` macro from `assert.h`. A different implementation of the function `demo_handle_err` directly uses the `assert` macro instead of taking the address of an `assert` function.

```
#include<assert.h>
void demo_handle_err(int err_code) {
    assert(err_code == 0);
}

void func(int err_code) {
    demo_handle_err(err_code);
}
```

Check Information

Group: Rule 48. Miscellaneous (MSC)

See Also

External Websites

MSC38-C

Introduced in R2019a

CERT C: Rule MSC39-C

Do not call va_arg() on a va_list that has an indeterminate value

Description

Rule Definition

Do not call va_arg() on a va_list that has an indeterminate value.

Examples

Invalid va_list argument

Description

Invalid va_list argument occurs when you use a `va_list` variable as an argument to a function in the `vprintf` group but:

- You do not initialize the variable previously using `va_start` or `va_copy`.
- You invalidate the variable previously using `va_end` and do not reinitialize it.

For instance, you call the function `vsprintf` as `vsprintf (buffer,format, args)`. However, before the function call, you do not initialize the `va_list` variable `args` using either of the following:

- `va_start(args, paramName)`. `paramName` is the last named argument of a variable-argument function. For instance, for the function definition `void func(int n, char c, ...) {}`, `c` is the last named argument.
- `va_copy(args, anotherList)`. `anotherList` is another valid `va_list` variable.

Risk

The behavior of an uninitialized `va_list` argument is undefined. Calling a function with an uninitialized `va_list` argument can cause stack overflows.

Fix

Before using a `va_list` variable as function argument, initialize it with `va_start` or `va_copy`.

Clean up the variable using `va_end` only after all uses of the variable.

Example - `va_list` Variable Used Following Call to `va_end`

```
#include <stdarg.h>
#include <stdio.h>

int call_vfprintf(int line, const char *format, ...) {
    va_list ap;
    int r=0;

    va_start(ap, format);
    r = vfprintf(stderr, format, ap);
    va_end(ap);

    r += vfprintf(stderr, format, ap);
    return r;
}
```

In this example, the `va_list` variable `ap` is used in the `vfprintf` function, after the `va_end` macro is called.

Correction — Call `va_end` After Using `va_list` Variable

One possible correction is to call `va_end` only after all uses of the `va_list` variable.

```
#include <stdarg.h>
#include <stdio.h>

int call_vfprintf(int line, const char *format, ...) {
    va_list ap;
    int r=0;

    va_start(ap, format);
    r = vfprintf(stderr, format, ap);
    r += vfprintf(stderr, format, ap);
    va_end(ap);

    return r;
}
```

Too many va_arg calls for current argument list

Description

Too many va_arg calls for current argument list occurs when the number of calls to `va_arg` exceeds the number of arguments passed to the corresponding variadic function. The analysis raises a defect only when the variadic function is called.

Too many va_arg calls for current argument list does not raise a defect when:

- The number of calls to `va_arg` inside the variadic function is indeterminate. For example, if the calls are from an external source.
- The `va_list` used in `va_arg` is invalid.

Risk

When you call `va_arg` and there is no next argument available in `va_list`, the behavior is undefined. The call to `va_arg` might corrupt data or return an unexpected result.

Fix

Ensure that you pass the correct number of arguments to the variadic function.

Example - No Argument Available When Calling `va_arg`

```
#include <stdarg.h>
#include <stddef.h>
#include <math.h>

/* variadic function defined with
* one named argument 'count'
*/
int variadic_func(int count, ...) {
    int result = -1;
    va_list ap;
    va_start(ap, count);
    if (count > 0) {
        result = va_arg(ap, int);
        count --;
        if (count > 0) {
/* No further argument available
* in va_list when calling va_arg
*/
```

```
            result += va_arg(ap, int);
        }
    }
    va_end(ap);
    return result;
}

void func(void) {

    (void)variadic_func(2, 100);

}
```

In this example, the named argument and only one variadic argument are passed to `variadic_func()` when it is called inside `func()`. On the second call to `va_arg`, no further variadic argument is available in `ap` and the behavior is undefined.

Correction — Pass Correct Number of Arguments to Variadic Function

One possible correction is to ensure that you pass the correct number of arguments to the variadic function.

```
#include <stdarg.h>
#include <stddef.h>
#include <math.h>

/* variadic function defined with
* one named argument 'count'
*/

int variadic_func(int count, ...) {
    int result = -1;
    va_list ap;
    va_start(ap, count);
    if (count > 0) {
        result = va_arg(ap, int);
        count --;
        if (count > 0) {

/* The correct number of arguments is
* passed to va_list when variadic_func()
* is called inside func()
*/
```

```
            result += va_arg(ap, int);
        }
    }
    va_end(ap);
    return result;
}

void func(void) {

    (void)variadic_func(2, 100, 200);

}
```

Check Information

Group: Rule 48. Miscellaneous (MSC)

See Also

External Websites

MSC39-C

Introduced in R2019a

CERT C: Rule MSC40-C

Do not violate constraints

Description

Rule Definition

Do not violate constraints.

Examples

Inline constraint not respected

Description

Inline constraint not respected occurs when you refer to a file scope modifiable static variable or define a local modifiable static variable in a nonstatic inlined function. The checker considers a variable as modifiable if it is not `const`-qualified.

For instance, `var` is a modifiable `static` variable defined in an `inline` function `func`. `g_step` is a file scope modifiable static variable referred to in the same inlined function.

```
static int g_step;
inline void func (void) {
   static int var = 0;
   var += g_step;
}
```

Risk

When you modify a static variable in multiple function calls, you expect to modify the same variable in each call. For instance, each time you call `func`, the same instance of `var1` is incremented but a separate instance of `var2` is incremented.

```
void func(void) {
   static var1 = 0;
```

```
    var2 = 0;
    var1++;
    var2++;
}
```

If a function has an inlined and non-inlined definition (in separate files), when you call the function, the C standard allows compilers to use either the inlined or the non-inlined form (see ISO/IEC 9899:2011, sec. 6.7.4). If your compiler uses an inlined definition in one call and the non-inlined definition in another, you are no longer modifying the same variable in both calls. This behavior defies the expectations from a static variable.

Fix

Use one of these fixes:

- If you do not intend to modify the variable, declare it as `const`.

  If you do not modify the variable, there is no question of unexpected modification.
- Make the variable non-`static`. Remove the `static` qualifier from the declaration.

  If the variable is defined in the function, it becomes a regular local variable. If defined at file scope, it becomes an extern variable. Make sure that this change in behavior is what you intend.
- Make the function `static`. Add a `static` qualifier to the function definition.

  If you make the function `static`, the file with the inlined definition always uses the inlined definition when the function is called. Other files use another definition of the function. The question of which function definition gets used is not left to the compiler.

Example - Static Variable Use in Inlined and External Definition

```
/* file1. c  : contains inline definition of get_random()*/

inline unsigned int get_random(void)
{

    static unsigned int m_z = 0xdeadbeef;
    static unsigned int m_w = 0xbaddecaf;

    /* Compute next pseudorandom value and update seeds */
    m_z = 36969 * (m_z & 65535) + (m_z >> 16);
    m_w = 18000 * (m_w & 65535) + (m_w >> 16);
    return (m_z << 16) + m_w;
```

```
}


int call_get_random(void)
{
    unsigned int rand_no;
    int ii;
    for (ii = 0; ii < 100; ii++) {
         rand_no = get_random();
    }
    rand_no = get_random();
    return 0;
}

/* file2. c  : contains external definition of get_random()*/

extern unsigned int get_random(void)
{
    /* Initialize seeds */
    static unsigned int m_z = 0xdeadbeef;
    static unsigned int m_w = 0xbaddecaf;

    /* Compute next pseudorandom value and update seeds */
    m_z = 36969 * (m_z & 65535) + (m_z >> 16);
    m_w = 18000 * (m_w & 65535) + (m_w >> 16);
    return (m_z << 16) + m_w;
}
```

In this example, `get_random()` has an inline definition in `file1.c` and an external definition in `file2.c`. When `get_random` is called in `file1.c`, compilers are free to choose whether to use the inline or the external definition.

Depending on the definition used, you might or might not modify the version of `m_z` and `m_w` in the inlined version of `get_random()`. This behavior contradicts the usual expectations from a static variable. When you call `get_random()`, you expect to always modify the same `m_z` and `m_w`.

Correction — Make Inlined Function Static

One possible correction is to make the inlined `get_random()` static. Irrespective of your compiler, calls to `get_random()` in `file1.c` then use the inlined definition. Calls to `get_random()` in other files use the external definition. This fix removes the ambiguity about which definition is used and whether the static variables in that definition are modified.

```
/* file1. c  : contains inline definition of get_random()*/

static inline unsigned int get_random(void)
{

    static unsigned int m_z = 0xdeadbeef;
    static unsigned int m_w = 0xbaddecaf;

    /* Compute next pseudorandom value and update seeds */
    m_z = 36969 * (m_z & 65535) + (m_z >> 16);
    m_w = 18000 * (m_w & 65535) + (m_w >> 16);
    return (m_z << 16) + m_w;
}


int call_get_random(void)
{
    unsigned int rand_no;
    int ii;
    for (ii = 0; ii < 100; ii++) {
         rand_no = get_random();
    }
    rand_no = get_random();
    return 0;
}

/* file2. c  : contains external definition of get_random()*/

extern unsigned int get_random(void)
{
    /* Initialize seeds */
    static unsigned int m_z = 0xdeadbeef;
    static unsigned int m_w = 0xbaddecaf;

    /* Compute next pseudorandom value and update seeds */
    m_z = 36969 * (m_z & 65535) + (m_z >> 16);
    m_w = 18000 * (m_w & 65535) + (m_w >> 16);
    return (m_z << 16) + m_w;
}
```

Check Information

Group: Rule 48. Miscellaneous (MSC)

See Also

External Websites

MSC40-C

Introduced in R2019a

Rule 50. POSIX (POS)

CERT C: Rule POS30-C

Use the readlink() function properly

Description

Rule Definition

Use the readlink() function properly.

Examples

Misuse of readlink()

Description

Misuse of readlink() occurs when you pass a buffer size argument to `readlink()` that does not leave space for a null terminator in the buffer.

For instance:

```
ssize_t len = readlink("/usr/bin/perl", buf, sizeof(buf));
```

The third argument is exactly equal to the size of the second argument. For large enough symbolic links, this use of `readlink()` does not leave space to enter a null terminator.

Risk

The `readlink()` function copies the content of a symbolic link (first argument) to a buffer (second argument). However, the function does not append a null terminator to the copied content. After using `readlink()`, you must explicitly add a null terminator to the buffer.

If you fill the entire buffer when using `readlink`, you do not leave space for this null terminator.

Fix

When using the `readlink()` function, make sure that the third argument is one less than the buffer size.

Then, append a null terminator to the buffer. To determine where to add the null terminator, check the return value of `readlink()`. If the return value is -1, an error has occurred. Otherwise, the return value is the number of characters (bytes) copied.

Example - Incorrect Size Argument of `readlink`

```
#include <unistd.h>

#define SIZE1024 1024

extern void display_path(const char *);

void func() {
    char buf[SIZE1024];
    ssize_t len = readlink("/usr/bin/perl", buf, sizeof(buf));
    if (len > 0) {
        buf[len - 1] = '\0';
    }
    display_path(buf);
}
```

In this example, the third argument of `readlink` is exactly the size of the buffer (second argument). If the first argument is long enough, this use of `readlink` does not leave space for the null terminator.

Also, if no characters are copied, the return value of `readlink` is 0. The following statement leads to a buffer underflow when `len` is 0.

```
buf[len - 1] = '\0';
```

Correction — Make Sure Size Argument is One Less Than Buffer Size

One possible correction is to make sure that the third argument of `readlink` is one less than size of the second argument.

The following corrected code also accounts for `readlink` returning 0.

```
#include <stdlib.h>
#include <unistd.h>
```

```
#define fatal_error() abort()
#define SIZE1024 1024

extern void display_path(const char *);

void func() {
    char buf[SIZE1024];
    ssize_t len = readlink("/usr/bin/perl", buf, sizeof(buf) - 1);
    if (len != -1) {
        buf[len] = '\0';
        display_path(buf);
    }
    else {
        /* Handle error */
        fatal_error();
    }
}
```

Check Information

Group: Rule 50. POSIX (POS)

See Also

External Websites

POS30-C

Introduced in R2019a

CERT C: Rule POS33-C

Do not use vfork()

Description

Rule Definition

Do not use vfork().

Examples

Use of obsolete standard function

Description

Use of obsolete standard function detects calls to standard function routines that are considered legacy, removed, deprecated, or obsolete by C/C++ coding standards.

Obsolete Function	Standards	Risk	Replacement Function
`asctime`	Deprecated in POSIX.1-2008	Not thread-safe.	`strftime` or `asctime_s`
`asctime_r`	Deprecated in POSIX.1-2008	Implementation based on unsafe function `sprintf`.	`strftime` or `asctime_s`
`bcmp`	Deprecated in 4.3BSD Marked as legacy in POSIX.1-2001.	Returns from function after finding the first differing byte, making it vulnerable to timing attacks.	`memcmp`

Obsolete Function	Standards	Risk	Replacement Function
`bcopy`	Deprecated in 4.3BSD Marked as legacy in POSIX.1-2001.	Returns from function after finding the first differing byte, making it vulnerable to timing attacks.	`memcpy` or `memmove`
`brk` and `sbrk`	Marked as legacy in SUSv2 and POSIX.1-2001.		`malloc`
`bsd_signal`	Removed in POSIX.1-2008		`sigaction`
`bzero`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`memset`
`ctime`	Deprecated in POSIX.1-2008	Not thread-safe.	`strftime` or `asctime_s`
`ctime_r`	Deprecated in POSIX.1-2008	Implementation based on unsafe function `sprintf`.	`strftime` or `asctime_s`
`cuserid`	Removed in POSIX.1-2001.	Not reentrant. Precise functionality not standardized causing portability issues.	`getpwuid`
`ecvt` and `fcvt`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008	Not reentrant	`snprintf`
`ecvt_r` and `fcvt_r`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008		`snprintf`
`ftime`	Removed in POSIX.1-2008		`time`, `gettimeofday`, `clock_gettime`
`gamma`, `gammaf`, `gammal`	Function not specified in any standard because of historical variations	Portability issues.	`tgamma`, `lgamma`

Obsolete Function	Standards	Risk	Replacement Function
`gcvt`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`snprintf`
`getcontext`	Removed in POSIX.1-2008.	Portability issues.	Use POSIX thread instead.
`getdtablesize`	BSD API function not included in POSIX.1-2001	Portability issues.	`sysconf( _SC_OPEN_MAX )`
`gethostbyaddr`	Removed in POSIX.1-2008	Not reentrant	`getaddrinfo`
`gethostbyname`	Removed in POSIX.1-2008	Not reentrant	`getnameinfo`
`getpagesize`	BSD API function not included in POSIX.1-2001	Portability issues.	`sysconf( _SC_PAGESIZE )`
`getpass`	Removed in POSIX.1-2001.	Not reentrant.	`getpwuid`
`getw`	Not present in POSIX.1-2001.		`fread`
`getwd`	Marked legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`getcwd`
`index`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`strchr`
`makecontext`	Removed in POSIX.1-2008.	Portability issues.	Use POSIX thread instead.
`memalign`	Appears in SunOS 4.1.3. Not in 4.4 BSD or POSIX.1-2001		`posix_memalign`
`mktemp`	Removed in POSIX.1-2008.	Generated names are predictable and can cause a race condition.	`mkstemp` removes race risk
`pthread_attr_getstackaddr` and `pthread_attr_setstackaddr`		Ambiguities in the specification of the `stackaddr` attribute cause portability issues	`pthread_attr_getstack` and `pthread_attr_setstack`
`putw`	Not present in POSIX.1-2001.	Portability issues.	`fwrite`

Obsolete Function	Standards	Risk	Replacement Function
`qecvt` and `qfcvt`	Marked as legacy in POSIX.1-2001, removed in POSIX.1-2008		`snprintf`
`qecvt_r` and `qfcvt_r`	Marked as legacy in POSIX.1-2001, removed in POSIX.1-2008		`snprintf`
`rand_r`	Marked as obsolete in POSIX.1-2008		
`re_comp`	BSD API function	Portability issues	`regcomp`
`re_exes`	BSD API function	Portability issues	`regexec`
`rindex`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`strrchr`
`scalb`	Removed in POSIX.1-2008		`scalbln`, `scalblnf`, or `scalblnl`
`sigblock`	4.3BSD signal API whose origin is unclear		`sigprocmask`
`sigmask`	4.3BSD signal API whose origin is unclear		`sigprocmask`
`sigsetmask`	4.3BSD signal API whose origin is unclear		`sigprocmask`
`sigstack`	Interface is obsolete and not implemented on most platforms.	Portability issues.	`sigaltstack`
`sigvec`	4.3BSD signal API whose origin is unclear		`sigaction`
`swapcontext`	Removed in POSIX.1-2008	Portability issues.	Use POSIX threads.

Obsolete Function	Standards	Risk	Replacement Function
`tmpnam` and `tmpnam_r`	Marked as obsolete in POSIX.1-2008.	This function generates a different string each time it is called, up to TMP_MAX times. If it is called more than TMP_MAX times, the behavior is implementation-defined.	`mkstemp`, `tmpfile`
`ttyslot`	Removed in POSIX.1-2001.		
`ualarm`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.	Errors are under-specified	`setitimer` or POSIX `timer_create`
`usleep`	Removed in POSIX.1-2008.		`nanosleep`
`utime`	SVr4, POSIX.1-2001. POSIX.1-2008 marks as obsolete.		
`valloc`	Marked as obsolete in 4.3BSD. Marked as legacy in SUSv2. Removed from POSIX.1-2001		`posix_memalign`
`vfork`	Removed from POSIX.1-2008	Under-specified in previous standards.	`fork`
`wcswcs`	This function was not included in the final ISO/IEC 9899:1990/ Amendment 1:1995 (E).		`wcsstr`
`WinExec`	WinAPI provides this function only for 16-bit Windows compatibility.		`CreateProcess`
`LoadModule`	WinAPI provides this function only for 16-bit Windows compatibility.		`CreateProcess`

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Printing Out Time

```
#include <stdio.h>
#include <time.h>

void timecheck_bad(int argc, char *argv[])
{
    time_t ticks;

    ticks = time(NULL);
    printf("%.24s\r\n", ctime(&ticks));
}
```

In this example, the function `ctime` formats the current time and prints it out. However, `ctime` was removed after C99 because it does not work on multithreaded programs.

Correction — Different Time Function

One possible correction is to use `strftime` instead because this function uses a set buffer size.

```
#include <stdio.h>
#include <string.h>
#include <time.h>

void timecheck_good(int argc, char *argv[])
{
    char outBuff[1025];
    time_t ticks;
    struct tm * timeinfo;

    memset(outBuff, 0, sizeof(outBuff));
```

```
    ticks = time(NULL);
    timeinfo = localtime(&ticks);
    strftime(outBuff,sizeof(outBuff),"%I:%M%p.",timeinfo);
    fprintf(stdout, outBuff);
}
```

Check Information

Group: Rule 50. POSIX (POS)

See Also

External Websites

POS33-C

Introduced in R2019a

CERT C: Rule POS34-C

Do not call putenv() with a pointer to an automatic variable as the argument

Description

Rule Definition

Do not call putenv() with a pointer to an automatic variable as the argument.

Examples

Use of automatic variable as putenv-family function argument

Description

Use of automatic variable as `putenv`-family function argument occurs when the argument of a `putenv`-family function is a local variable with automatic duration.

Risk

The function `putenv(char *string)` inserts a pointer to its supplied argument into the environment array, instead of making a copy of the argument. If the argument is an automatic variable, its memory can be overwritten after the function containing the `putenv()` call returns. A subsequent call to `getenv()` from another function returns the address of an out-of-scope variable that cannot be dereferenced legally. This out-of-scope variable can cause environment variables to take on unexpected values, cause the program to stop responding, or allow arbitrary code execution vulnerabilities.

Fix

Use `setenv()`/`unsetenv()` to set and unset environment variables. Alternatively, use `putenv`-family function arguments with dynamically allocated memory, or, if your application has no reentrancy requirements, arguments with static duration. For example, a single thread execution with no recursion or interrupts does not require reentrancy. It cannot be called (reentered) during its execution.

Example - Automatic Variable as Argument of `putenv()`

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define SIZE1024 1024

void func(int var)
{
    char env[SIZE1024];
    int retval = sprintf(env, "TEST=%s", var ? "1" : "0");
    if (retval <= 0) {
        /* Handle error */
    }
    /* Environment variable TEST is set using putenv().
    The argument passed to putenv is an automatic variable. */
    retval = putenv(env);
    if (retval != 0) {
        /* Handle error */
    }
}
```

In this example, `sprintf()` stores the character string `TEST=var` in `env`. The value of the environment variable `TEST` is then set to `var` by using `putenv()`. Because `env` is an automatic variable, the value of `TEST` can change once `func()` returns.

Correction — Use `static` Variable for Argument of `putenv()`

Declare `env` as a static-duration variable. The memory location of `env` is not overwritten for the duration of the program, even after `func()` returns.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define SIZE1024 1024
void func(int var)
{
    /* static duration variable */
    static char env[SIZE1024];
    int retval = sprintf(env,"TEST=%s", var ? "1" : "0");
    if (retval <= 0) {
```

```
        /* Handle error */
    }

    /* Environment variable TEST is set using putenv() */
    retval=putenv(env);
    if (retval != 0) {
        /* Handle error */
    }
}
```

Correction — Use `setenv()` to Set Environment Variable Value

To set the value of `TEST` to `var`, use `setenv()`.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define SIZE1024 1024

void func(int var)
{
    /* Environment variable TEST is set using setenv() */
    int retval = setenv("TEST", var ? "1" : "0", 1);

    if (retval != 0) {
        /* Handle error */
    }
}
```

Check Information

Group: Rule 50. POSIX (POS)

See Also

External Websites

POS34-C

Introduced in R2019a

CERT C: Rule POS35-C

Avoid race conditions while checking for the existence of a symbolic link

Description

Rule Definition

Avoid race conditions while checking for the existence of a symbolic link.

Examples

File access between time of check and use (TOCTOU)

Description

File access between time of check and use (TOCTOU) detects race condition issues between checking the existence of a file or folder, and using a file or folder.

Risk

An attacker can access and manipulate your file between your check for the file and your use of a file. Symbolic links are particularly risky because an attacker can change where your symbolic link points.

Fix

Before using a file, do not check its status. Instead, use the file and check the results afterward.

Example - Check File Before Using

```
#include <stdio.h>
#include <fcntl.h>
#include <unistd.h>
```

```
extern void print_tofile(FILE* f);

void toctou(char * log_path) {
    if (access(log_path, W_OK)==0) {
        FILE* f = fopen(log_path, "w");
        if (f) {
            print_tofile(f);
            fclose(f);
        }
    }
}
```

In this example, before opening and using the file, the function checks if the file exists. However, an attacker can change the file between the first and second lines of the function.

Correction — Open Then Check

One possible correction is to open the file, and then check the existence and contents afterward.

```
#include <stdio.h>
#include <fcntl.h>
#include <unistd.h>

extern void print_tofile(FILE* f);

void toctou(char * log_path) {
    int fd = open(log_path, O_WRONLY);
    if (fd!=-1) {
        FILE *f = fdopen(fd, "w");
        if (f) {
            print_tofile(f);
            fclose(f);
        }
    }
}
```

Check Information

Group: Rule 50. POSIX (POS)

See Also

External Websites

POS35-C

Introduced in R2019a

CERT C: Rule POS36-C

Observe correct revocation order while relinquishing privileges

Description

Rule Definition

Observe correct revocation order while relinquishing privileges.

Examples

Bad order of dropping privileges

Description

Bad order of dropping privileges checks the order of privilege drops. If you drop higher elevated privileges before dropping lower elevated privileges, Polyspace raises a defect. For example dropping elevated primary group privileges before dropping elevated ancillary group privileges.

Risk

If you drop privileges in the wrong order, you can potentially drop higher privileges that you need to drop lower privileges. The incorrect order can mean, privileges are not dropped, compromising the security of your program.

Fix

Respect this order of dropping elevated privileges:

- Drop (elevated) ancillary group privileges, then drop (elevated) primary group privileges.
- Drop (elevated) primary group privileges, then drop (elevated) user privileges.

Example - Dropping User Privileges First

```
#define _BSD_SOURCE
#include <sys/types.h>
#include <unistd.h>
#include <grp.h>
#include <stdlib.h>
#define fatal_error() abort()

static void sanitize_privilege_drop_check(uid_t olduid, gid_t oldgid)
{
    if (seteuid(olduid) != -1)
    {
        /* Privileges can be restored, handle error */
        fatal_error();
    }
    if (setegid(oldgid) != -1)
    {
        /* Privileges can be restored, handle error */
        fatal_error();
    }
}
void badprivilegedroporder(void) {
    uid_t
        newuid = getuid(),
        olduid = geteuid();
    gid_t
        newgid = getgid(),
        oldgid = getegid();

    if (setuid(newuid) == -1) {
        /* handle error condition */
        fatal_error();
    }
    if (setgid(newgid) == -1)  {
        /* handle error condition */
        fatal_error();
    }
    if (olduid == 0) {
        /* drop ancillary groups IDs only possible for root */
        if (setgroups(1, &newgid) == -1) {
            /* handle error condition */
            fatal_error();
        }
```

```
    }

    sanitize_privilege_drop_check(olduid, oldgid);
}
```

In this example, there are two privilege drops made in the incorrect order. `setgid` attempts to drop group privileges. However, `setgid` requires the user privileges, which were dropped previously using `setuid`, to perform this function. After dropping group privileges, this function attempts to drop ancillary groups privileges by using `setgroups`. This task requires the higher primary group privileges that were dropped with `setgid`. At the end of this function, it is possible to regain group privileges because the order of dropping privileges was incorrect.

Correction — Reverse Privilege Drop Order

One possible correction is to drop the lowest level privileges first. In this correction, ancillary group privileges are dropped, then primary group privileges are dropped, and finally user privileges are dropped.

```
#define _BSD_SOURCE
#include <sys/types.h>
#include <unistd.h>
#include <grp.h>
#include <stdlib.h>
#define fatal_error() abort()

static void sanitize_privilege_drop_check(uid_t olduid, gid_t oldgid)
{
    if (seteuid(olduid) != -1)
    {
        /* Privileges can be restored, handle error */
        fatal_error();
    }
    if (setegid(oldgid) != -1)
    {
        /* Privileges can be restored, handle error */
        fatal_error();
    }
}
void badprivilegedroporder(void) {
    uid_t
        newuid = getuid(),
        olduid = geteuid();
    gid_t
```

```
        newgid = getgid(),
        oldgid = getegid();

    if (olduid == 0) {
        /* drop ancillary groups IDs only possible for root */
        if (setgroups(1, &newgid) == -1) {
            /* handle error condition */
            fatal_error();
        }
    }
    if (setgid(getgid()) == -1)  {
        /* handle error condition */
        fatal_error();
    }
    if (setuid(getuid()) == -1) {
        /* handle error condition */
        fatal_error();
    }

    sanitize_privilege_drop_check(olduid, oldgid);
}
```

Check Information

Group: Rule 50. POSIX (POS)

See Also

External Websites

POS36-C

Introduced in R2019a

CERT C: Rule POS37-C

Ensure that privilege relinquishment is successful

Description

Rule Definition

Ensure that privilege relinquishment is successful.

Examples

Privilege drop not verified

Description

Privilege drop not verified detects calls to functions that relinquish privileges. If you do not verify that the privileges were dropped before the end of your function, a defect is raised.

Risk

If privilege relinquishment fails, an attacker can regain elevated privileges and have more access to your program than intended. This security hole can cause unexpected behavior in your code if left open.

Fix

Before the end of scope, verify that the privileges that you dropped were actually dropped.

Example - Drop Privileges Within a Function

```
#define _BSD_SOURCE
#include <sys/types.h>
#include <unistd.h>
```

```
#include <grp.h>
#include <stdlib.h>
#define fatal_error() abort()
extern int need_more_privileges;

void missingprivilegedropcheck()
{
    /* Code intended to run with elevated privileges */

    /* Temporarily drop elevated privileges */
    if (seteuid(getuid()) != 0) {
        /* Handle error */
        fatal_error();
    }

    /* Code intended to run with lower privileges */

    if (need_more_privileges) {
        /* Restore elevated privileges */
        if (seteuid(0) != 0) {
            /* Handle error */
            fatal_error();
        }
        /* Code intended to run with elevated privileges */
    }

    /* ... */

    /* Permanently drop elevated privileges */
    if (setuid(getuid()) != 0) {
        /* Handle error */
        fatal_error();
    }

    /* Code intended to run with lower privileges */
}
```

In this example, privileges are elevated and dropped to run code with the intended privilege level. When privileges are dropped, the privilege level before exiting the function body is not verified. A malicious attacker can regain their elevated privileges.

Correction — Verify Privilege Drop

One possible correction is to use `setuid` to verify that the privileges were dropped.

```
#define _BSD_SOURCE
#include <sys/types.h>
#include <unistd.h>
#include <grp.h>
#include <stdlib.h>
#define fatal_error() abort()
extern int need_more_privileges;

void missingprivilegedropcheck()
{
    /* Store the privileged ID for later verification */
    uid_t privid = geteuid();

    /* Code intended to run with elevated privileges   */

    /* Temporarily drop elevated privileges */
    if (seteuid(getuid()) != 0) {
        /* Handle error */
        fatal_error();
    }

    /* Code intended to run with lower privileges  */

    if (need_more_privileges) {
        /* Restore elevated Privileges */
        if (seteuid(privid) != 0) {
            /* Handle error */
            fatal_error();
        }
        /* Code intended to run with elevated privileges   */
    }

    /* ... */

    /* Restore privileges if needed */
    if (geteuid() != privid) {
        if (seteuid(privid) != 0) {
            /* Handle error */
            fatal_error();
        }
    }

    /* Permanently drop privileges */
    if (setuid(getuid()) != 0) {
```

```
        /* Handle error */
        fatal_error();
    }

    if (setuid(0) != -1) {
        /* Privileges can be restored, handle error */
        fatal_error();
    }

    /* Code intended to run with lower privileges; */
}
```

Check Information

Group: Rule 50. POSIX (POS)

See Also

External Websites

POS37-C

Introduced in R2019a

CERT C: Rule POS38-C

Beware of race conditions when using fork and file descriptors

Description

Rule Definition

Beware of race conditions when using fork and file descriptors.

Examples

File descriptor exposure to child process

Description

File descriptor exposure to child process occurs when a process is forked and the child process uses file descriptors inherited from the parent process.

Risk

When you fork a child process, file descriptors are copied from the parent process, which means that you can have concurrent operations on the same file. Use of the same file descriptor in the parent and child processes can lead to race conditions that may not be caught during standard debugging. If you do not properly manage the file descriptor permissions and privileges, the file content is vulnerable to attacks targeting the child process.

Fix

Check that the file has not been modified before forking the process. Close all inherited file descriptors and reopen them with stricter permissions and privileges, such as read-only permission.

Example - File Descriptor Accessed from Forked Process

```
# include <stdio.h>
# include <stdlib.h>
# include <string.h>
# include <unistd.h>
# include <fcntl.h>
# include <sys/types.h>
# include <sys/stat.h>



const char *test_file="/home/user/test.txt";

void func(void)
{
    char c;
    pid_t pid;
    /* create file descriptor in read and write mode */
    int fd = open(test_file, O_RDWR);
    if (fd == -1)
    {
        /* Handle error */
        abort();
    }
    /* fork process */
    pid = fork();
    if (pid == -1)
    {
        /* Handle error */
        abort();
    }
    else if (pid == 0)
    {   /* Child process accesses file descriptor inherited
        from parent process */
        (void)read(fd, &c, 1);
    }
    else
    {   /* Parent process access same file descriptor as
        child process */
        (void)read(fd, &c, 1);
    }
}
```

In this example, a file descriptor `fd` is created in read and write mode. The process is then forked. The child process inherits and accesses `fd` with the same permissions as the parent process. A race condition exists between the parent and child processes. The contents of the file is vulnerable to attacks through the child process.

Correction — Close and Reopen Inherited File Descriptor

After you create the file descriptor, check the file for tampering. Then, close the inherited file descriptor in the child process and reopen it in read-only mode.

```
# include <stdio.h>
# include <stdlib.h>
# include <string.h>
# include <unistd.h>
# include <fcntl.h>
# include <sys/types.h>
# include <sys/stat.h>


const char *test_file="/home/user/test.txt";

void func(void)
{
    char c;
    pid_t pid;

    /* Get the state of file for further file tampering checking */

    /* create file descriptor in read and write mode */
    int fd = open(test_file, O_RDWR);
    if (fd == -1)
    {
        /* Handle error */
        abort();
    }

    /* Be sure the file was not tampered with while opening */

    /* fork process */

    pid = fork();
    if (pid == -1)
    {
        /* Handle error */
```

```
        (void)close(fd);
        abort();
    }
    else if (pid == 0)
    {  /* Close file descriptor in child process and repoen
        it in read only mode */

        (void)close(fd);
        fd = open(test_file, O_RDONLY);
        if (fd == -1)
        {
            /* Handle error */
            abort();
        }


        (void)read(fd, &c, 1);
        (void)close(fd);
    }
    else
    {  /* Parent acceses original file descriptor */
        (void)read(fd, &c, 1);
        (void)close(fd);
    }
}
```

Check Information

Group: Rule 50. POSIX (POS)

See Also

External Websites

POS38-C

Introduced in R2019a

CERT C: Rule POS39-C

Use the correct byte ordering when transferring data between systems

Description

Rule Definition

Use the correct byte ordering when transferring data between systems.

Examples

Missing byte reordering when transferring data

Description

Missing byte reordering when transferring data occurs when you do not use a byte ordering function:

- Before sending data to a network socket.
- After receiving data from a network socket.

Risk

Some system architectures implement little endian byte ordering (least significant byte first), and other systems implement big endian (most significant byte first). If the endianness of the sent data does not match the endianness of the receiving system, the value returned when reading the data is incorrect.

Fix

After receiving data from a socket, use a byte ordering function such as `ntohl()`. Before sending data to a socket, use a byte ordering function such as `htonl()` .

Example - Data Transferred Without Byte Reordering

```
#include <stdio.h>
#include <stdlib.h>
#include <stdint.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <arpa/inet.h>
#include <byteswap.h>
#include <unistd.h>
#include <string.h>


unsigned int func(int sock, int server)
{
    unsigned int num;   /* assume int is 32-bits */
    if (server)
    {
        /* Server side */
        num = 0x17;
        /* Endianness of server host may not match endianness of network. */
        if (send(sock, (void *)&num, sizeof(num), 0) < (int)sizeof(num))
        {
            /* Handle error */
        }
        return 0;
    }
    else {
        /* Endianness of client host may not match endianness of network. */
        if (recv (sock, (void *)&num, sizeof(num), 0) < (int) sizeof(num))
        {
            /* Handle error */
        }

        /* Comparison may be inaccurate */
        if (num> 255)
        {
            return 255;
        }
        else
        {
            return num;
        }
    }
```

```
}
```

In this example, variable `num` is assigned hexadecimal value `0x17` and is sent over a network to the client from the server. If the server host is little endian and the network is big endian, `num` is transferred as `0x17000000`. The client then reads an incorrect value for `num` and compares it to a local numeric value.

Correction — Use Byte Ordering Function

Before sending `num` from the server host, use `htonl()` to convert from host to network byte ordering. Similarly, before reading `num` on the client host, use `ntohl()` to convert from network to host byte ordering.

```
#include <stdio.h>
#include <stdlib.h>
#include <stdint.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <arpa/inet.h>
#include <byteswap.h>
#include <unistd.h>
#include <string.h>

unsigned int func(int sock, int server)
{
    unsigned int num;   /* assume int is 32-bits */
    if (server)
    {
        /* Server side */
        num = 0x17;

        /* Convert to network byte order. */
        num = htonl(num);
        if (send(sock, (void *)&num, sizeof(num), 0) < (int)sizeof(num))
        {
            /* Handle error */
        }
        return 0;
    }
    else {
        if (recv (sock, (void *)&num, sizeof(num), 0) < (int) sizeof(num))
        {
```

```
            /* Handle error */
        }

        /* Convert to host byte order. */
        num = ntohl(num);
        if (num > 255)
        {
            return 255;
        }
        else
        {
            return num;
        }
    }
}
```

Check Information

Group: Rule 50. POSIX (POS)

See Also

External Websites

POS39-C

Introduced in R2019a

CERT C: Rule POS44-C

Do not use signals to terminate threads

Description

Rule Definition

Do not use signals to terminate threads.

Examples

Use of signal to kill thread

Description

Use of signal to kill thread occurs when you use an uncaught signal to kill a thread. For instance, you use the POSIX function `pthread_kill` and send the signal `SIGTERM` to kill a thread.

Risk

Sending a signal kills the entire process instead of just the thread that you intend to kill.

For instance, the `pthread_kill` specifications state that if the disposition of a signal is to terminate, this action affects the entire process.

Fix

Use other mechanisms that are intended to kill specific threads.

For instance, use the POSIX function `pthread_cancel` to terminate a specific thread.

Example - Use of `pthread_kill` to Terminate Threads

```
#include <signal.h>
#include <pthread.h>
```

```
void* func(void *foo) {
  /* Execution of thread */
}

int main(void) {
  int result;
  pthread_t thread;

  if ((result = pthread_create(&thread, NULL, func, 0)) != 0) {
  }
  if ((result = pthread_kill(thread, SIGTERM)) != 0) {
  }

  /* This point is not reached because the process terminates in pthread_kill() */

  return 0;
}
```

In this example, the `pthread_kill` function sends the signal `SIGTERM` to kill a thread. The signal kills the entire process instead of the thread previously created with `pthread_create`.

Correction — Use `pthread_cancel` to Terminate Threads

One possible correction is to use the `pthread_cancel` function. The `pthread_cancel` terminates a thread specified by its first argument at a specific cancellation point or immediately, depending on the thread's cancellation type.

```
#include <signal.h>
#include <pthread.h>

void* func(void *foo) {
  /* Execution of thread */
}

int main(void) {
  int result;
  pthread_t thread;

  if ((result = pthread_create(&thread, NULL, func, 0)) != 0) {
    /* Handle Error */
  }
  if ((result = pthread_cancel(thread)) != 0) {
```

```
    /* Handle Error */
  }

  /* Continue executing */

  return 0;
}
```

See also:

- `pthread_cancel` for more information on cancellation types.
- Pthreads for functions that are allowed to be cancellation points.

Check Information

Group: Rule 50. POSIX (POS)

See Also

External Websites

POS44-C

Introduced in R2019a

CERT C: Rule POS48-C

Do not unlock or destroy another POSIX thread's mutex

Description

Rule Definition

Do not unlock or destroy another POSIX thread's mutex.

Examples

Destruction of locked mutex

Description

Destruction of locked mutex occurs when a task destroys a mutex after it is locked (and before it is unlocked). The locking and destruction can happen in the same task or different tasks.

Risk

A mutex is locked to protect shared variables from concurrent access. If a mutex is destroyed in the locked state, the protection does not apply.

Fix

To fix this defect, destroy the mutex only after you unlock it. It is a good design practice to:

- Initialize a mutex *before* creating the threads where you use the mutex.
- Destroy a mutex *after* joining the threads that you created.

On the **Result Details** pane, you see two events, the locking and destruction of the mutex, and the tasks that initiated the events. To navigate to the corresponding line in your source code, click the event.

Example - Locking and Destruction in Different Tasks

```
#include <pthread.h>

pthread_mutex_t lock1;
pthread_mutex_t lock2;
pthread_mutex_t lock3;

void t0 (void) {
  pthread_mutex_lock (&lock1);
  pthread_mutex_lock (&lock2);
  pthread_mutex_lock (&lock3);
  pthread_mutex_unlock (&lock2);
  pthread_mutex_unlock (&lock1);
  pthread_mutex_unlock (&lock3);
}

void t1 (void) {
  pthread_mutex_lock (&lock1);
  pthread_mutex_lock (&lock2);
  pthread_mutex_destroy (&lock3);
  pthread_mutex_unlock (&lock2);
  pthread_mutex_unlock (&lock1);
}
```

In this example, after task `t0` locks the mutex `lock3`, task `t1` can destroy it. The destruction occurs if the following events happen in sequence:

1. `t0` acquires `lock3`.
2. `t0` releases `lock2`.
3. `t0` releases `lock1`.
4. `t1` acquires the lock `lock1` released by `t0`.
5. `t1` acquires the lock `lock2` released by `t0`.
6. `t1` destroys `lock3`.

For simplicity, this example uses a mix of automatic and manual concurrency detection. The tasks `t0` and `t1` are manually specified as entry points by using the option `Tasks (-entry-points)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server. The critical sections are

implemented through primitives `pthread_mutex_lock` and `pthread_mutex_unlock` that the software detects automatically. In practice, for entry point specification (thread creation), you will use primitives such as `pthread_create`. The next example shows how the defect can appear when you use `pthread_create`.

Correction — Place Lock-Unlock Pair Together in Same Critical Section as Destruction

The locking and destruction of `lock3` occurs inside the critical section imposed by `lock1` and `lock2`, but the unlocking occurs outside. One possible correction is to place the lock-unlock pair in the same critical section as the destruction of the mutex. Use one of these critical sections:

- Critical section imposed by `lock1` alone.
- Critical section imposed by `lock1` and `lock2`.

In this corrected code, the lock-unlock pair and the destruction is placed in the critical section imposed by `lock1` and `lock2`. When `t0` acquires `lock1` and `lock2`, `t1` has to wait for their release before it executes the instruction `pthread_mutex_destroy (&lock3);`. Therefore, `t1` cannot destroy mutex `lock3` in the locked state.

```
#include <pthread.h>

pthread_mutex_t lock1;
pthread_mutex_t lock2;
pthread_mutex_t lock3;

void t0 (void) {
  pthread_mutex_lock (&lock1);
  pthread_mutex_lock (&lock2);

  pthread_mutex_lock (&lock3);
  pthread_mutex_unlock (&lock3);

  pthread_mutex_unlock (&lock2);
  pthread_mutex_unlock (&lock1);
}

void t1 (void) {
  pthread_mutex_lock (&lock1);
  pthread_mutex_lock (&lock2);
```

```
  pthread_mutex_destroy (&lock3);

  pthread_mutex_unlock (&lock2);
  pthread_mutex_unlock (&lock1);
}
```

Example - Locking and Destruction in Start Routine of Thread

```
#include <pthread.h>

/* Define globally accessible variables and a mutex */
#define NUMTHREADS 4
pthread_t callThd[NUMTHREADS];
pthread_mutex_t lock;
void atomic_operation(void);

void *do_create(void *arg) {
    /* Creation thread */
    pthread_mutex_init(&lock, NULL);
    pthread_exit((void*) 0);
}

void *do_work(void *arg) {
    /* Worker thread */
    pthread_mutex_lock (&lock);
    atomic_operation();
    pthread_mutex_unlock (&lock);
    pthread_exit((void*) 0);
}

void *do_destroy(void *arg) {
    /* Destruction thread */
    pthread_mutex_destroy(&lock);
    pthread_exit((void*) 0);
}

int main (int argc, char *argv[]) {
   int i;
   void *status;
   pthread_attr_t attr;


   /* Create threads */
```

```
   pthread_attr_init(&attr);
   pthread_attr_setdetachstate(&attr, PTHREAD_CREATE_JOINABLE);

   /* Thread that initializes mutex */
   pthread_create(&callThd[0], &attr, do_create, NULL);

   /* Threads that use mutex for atomic operation*/
   for(i=0; i<NUMTHREADS-1; i++) {
      pthread_create(&callThd[i], &attr, do_work, (void *)i);
   }

   /* Thread that destroys mutex */
   pthread_create(&callThd[NUMTHREADS -1], &attr, do_destroy, NULL);

   pthread_attr_destroy(&attr);

   /* Join threads */
   for(i=0; i<NUMTHREADS; i++) {
      pthread_join(callThd[i], &status);
   }

   pthread_exit(NULL);
}
```

In this example, four threads are created. The threads are assigned different actions.

- The first thread `callThd[0]` initializes the mutex `lock`.
- The second and third threads, `callThd[1]` and `callThd[2]`, perform an atomic operation protected by the mutex `lock`.
- The fourth thread `callThd[3]` destroys the mutex `lock`.

The threads can interrupt each other. Therefore, immediately after the second or third thread locks the mutex, the fourth thread can destroy it.

Correction — Initialize and Destroy Mutex Outside Start Routine

One possible correction is to initialize and destroy the mutex in the `main` function outside the start routine of the threads. The threads perform only the atomic operation. You need two fewer threads because the mutex initialization and destruction threads are not required.

```
#include <pthread.h>
```

```
/* Define globally accessible variables and a mutex */
#define NUMTHREADS 2
pthread_t callThd[NUMTHREADS];
pthread_mutex_t lock;
void atomic_operation(void);

void *do_work(void *arg) {
   pthread_mutex_lock (&lock);
   atomic_operation();
   pthread_mutex_unlock (&lock);
   pthread_exit((void*) 0);
}

int main (int argc, char *argv[]) {
   int i;
   void *status;
   pthread_attr_t attr;


   /* Create threads */
   pthread_attr_init(&attr);
   pthread_attr_setdetachstate(&attr, PTHREAD_CREATE_JOINABLE);

   /* Initialize mutex */
   pthread_mutex_init(&lock, NULL);

   for(i=0; i<NUMTHREADS; i++) {
      pthread_create(&callThd[i], &attr, do_work, (void *)i);
   }

   pthread_attr_destroy(&attr);

   /* Join threads */
   for(i=0; i<NUMTHREADS; i++) {
      pthread_join(callThd[i], &status);
   }

   /* Destroy mutex */
   pthread_mutex_destroy(&lock);

   pthread_exit(NULL);
}
```

Correction — Use A Second Mutex To Protect Lock-Unlock Pair and Destruction

Another possible correction is to use a second mutex and protect the lock-unlock pair from the destruction. This corrected code uses the mutex `lock2` to achieve this protection. The second mutex is initialized in the `main` function outside the start routine of the threads.

```
#include <pthread.h>

/* Define globally accessible variables and a mutex */
#define NUMTHREADS 4
pthread_t callThd[NUMTHREADS];
pthread_mutex_t lock;
pthread_mutex_t lock2;
void atomic_operation(void);

void *do_create(void *arg) {
    /* Creation thread */
    pthread_mutex_init(&lock, NULL);
    pthread_exit((void*) 0);
}

void *do_work(void *arg) {
    /* Worker thread */
    pthread_mutex_lock (&lock2);
    pthread_mutex_lock (&lock);
    atomic_operation();
    pthread_mutex_unlock (&lock);
    pthread_mutex_unlock (&lock2);
    pthread_exit((void*) 0);
}

void *do_destroy(void *arg) {
    /* Destruction thread */
    pthread_mutex_lock (&lock2);
    pthread_mutex_destroy(&lock);
    pthread_mutex_unlock (&lock2);
    pthread_exit((void*) 0);
}


int main (int argc, char *argv[]) {
   int i;
   void *status;
```

```
   pthread_attr_t attr;


   /* Create threads */
   pthread_attr_init(&attr);
   pthread_attr_setdetachstate(&attr, PTHREAD_CREATE_JOINABLE);

   /* Initialize second mutex */
   pthread_mutex_init(&lock2, NULL);

   /* Thread that initializes first mutex */
   pthread_create(&callThd[0], &attr, do_create, NULL);

   /* Threads that use first mutex for atomic operation */
   /* The threads use second mutex to protect first from destruction in locked state*/
   for(i=0; i<NUMTHREADS-1; i++) {
      pthread_create(&callThd[i], &attr, do_work, (void *)i);
   }

   /* Thread that destroys first mutex */
   /* The thread uses the second mutex to prevent destruction of locked mutex */
   pthread_create(&callThd[NUMTHREADS -1], &attr, do_destroy, NULL);


   pthread_attr_destroy(&attr);

   /* Join threads */
   for(i=0; i<NUMTHREADS; i++) {
      pthread_join(callThd[i], &status);
   }

   /* Destroy second mutex */
   pthread_mutex_destroy(&lock2);

   pthread_exit(NULL);
}
```

Check Information

Group: Rule 50. POSIX (POS)

See Also

External Websites

POS48-C

Introduced in R2019a

CERT C: Rule POS49-C

When data must be accessed by multiple threads, provide a mutex and guarantee no adjacent data is also accessed

Description

Rule Definition

When data must be accessed by multiple threads, provide a mutex and guarantee no adjacent data is also accessed.

Examples

Data race

Description

Data race occurs when:

1. Multiple tasks perform unprotected operations on a shared variable.
2. At least one task performs a write operation.
3. At least one operation is nonatomic. For data race on both atomic and nonatomic operations, see `Data race including atomic operations`.

   See also the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**. For more information, see the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Data race can result in unpredictable values of the shared variable because you do not control the order of the operations in different tasks.

Data races between two write operations are more serious than data races between a write and read operation. Two write operations can interfere with each other and result in indeterminate values. To identify write-write conflicts, use the filters on the **Detail** column of the **Results List** pane. For these conflicts, the **Detail** column shows the additional line:

```
Variable value may be altered by write-write concurrent access.
```

See “Filter and Sort Results”.

Fix

To fix this defect, protect the operations on the shared variable using critical sections, temporal exclusion or another means. See the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server..

To identify existing protections that you can reuse, see the table and graphs associated with the result. The table shows each pair of conflicting calls. The **Access Protections** column shows existing protections on the calls. To see the function call sequence leading to the conflicts, click the  icon. For an example, see below.

Example - Unprotected Operation on Global Variable from Multiple Tasks

```
int var;
void begin_critical_section(void);
void end_critical_section(void);

void increment(void) {
    var++;
}

void task1(void)  {
      increment();
}

void task2(void)  {
      increment();
}

void task3(void)  {
```

```
    begin_critical_section();
    increment();
    end_critical_section();
}
```

In this example, to emulate multitasking behavior, specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	task1 task2 task3	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section	end_critical_section

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
  -entry-points task1,task2,task3
  -critical-section-begin begin_critical_section:cs1
  -critical-section-end end_critical_section:cs1
```

In this example, the tasks `task1`, `task2`, and `task3` call the function `increment`. `increment` contains the operation `var++` that can involve multiple machine instructions including:

- Reading `var`.
- Writing an increased value to `var`.

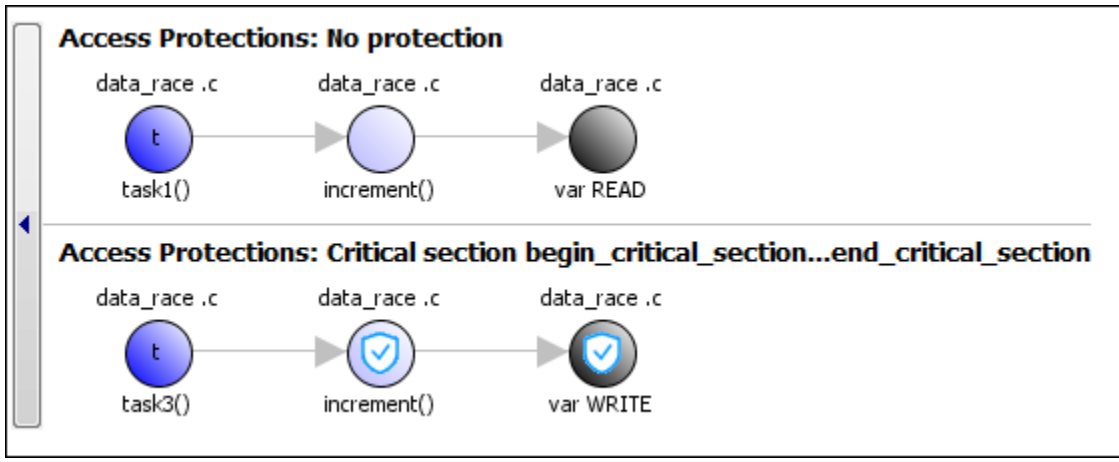
These machine instructions, when executed from `task1` and `task2`, can occur concurrently in an unpredictable sequence. For example, reading `var` from `task1` can occur either before or after writing to `var` from `task2`. Therefore the value of `var` can be unpredictable.

Though `task3` calls `increment` inside a critical section, other tasks do not use the same critical section. The operations in the critical section of `task3` are not mutually exclusive with operations in other tasks.

Therefore, the three tasks are operating on a shared variable without common protection. In your result details, you see each pair of conflicting function calls.

	Access	Access Protections	Task	File
	Read	No protection	task1()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	No protection	task2()	data_race .c
	Read	No protection	task1()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	**Critical section begin_critical_section...end_critical_section**	task3()	data_race .c
	Read	No protection	task2()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	**Critical section begin_critical_section...end_critical_section**	task3()	data_race .c

If you click the  icon, you see the function call sequence starting from the entry point to the read or write operation. You also see that the operation starting from `task3` is in a critical section. The **Access Protections** entry shows the lock and unlock function that begin and end the critical section. In this example, you see the functions `begin_critical_section` and `end_critical_section`.



Correction — Place Operation in Critical Section

One possible correction is to place the operation in critical section. You can implement the critical section in multiple ways. For instance:

- You can place `var++` in a critical section. When `task1` enters its critical section, the other tasks cannot enter their critical sections until `task1` leaves its critical section. The operation `var++` from the three tasks cannot interfere with each other.

  To implement the critical section, in the function `increment`, place the operation `var ++` between calls to `begin_critical_section` and `end_critical_section`.

```
int var;

void begin_critical_section(void);
void end_critical_section(void);

void increment(void) {
      begin_critical_section();
      var++;
      end_critical_section();
}

void task1(void)  {
      increment();
}

void task2(void)  {
      increment();
}

void task3(void)  {
      increment();
}
```

- You can place the call to `increment` in the same critical section in the three tasks. When `task1` enters its critical section, the other tasks cannot enter their critical sections until `task1` leaves its critical section. The calls to `increment` from the three tasks cannot interfere with each other.

  To implement the critical section, in each of the three tasks, call `increment` between calls to `begin_critical_section` and `end_critical_section`.

```
int var;

void begin_critical_section(void);
void end_critical_section(void);

void increment(void) {
      var++;
}

void task1(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}

void task2(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}

void task3(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}
```

Correction — Make Tasks Temporally Exclusive

Another possible correction is to make the tasks, `task1`, `task2` and `task3`, temporally exclusive. Temporally exclusive tasks cannot execute concurrently.

On the **Configuration** pane, specify the following additional options:

Option	Value
`Temporally exclusive tasks (-temporal-exclusions-file)`	`task1 task2 task3`

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
 polyspace-bug-finder
     -temporal-exclusions-file "C:\exclusions_file.txt"
```

where the file `C:\exclusions_file.txt` has the following line:

```
task1 task2 task3
```

Example - Unprotected Operation in Threads Created with `pthread_create`

```
#include <pthread.h>

pthread_mutex_t count_mutex;
long long count;


void* increment_count(void* args)
{
    count = count + 1;
    return NULL;
}

void* set_count(void *args)
{
    long long c;
    c = count;
    return NULL;
}

int main(void)
{
    pthread_t thread_increment;
    pthread_t thread_get;

    pthread_create(&thread_increment, NULL, increment_count, NULL);
    pthread_create(&thread_get, NULL, set_count, NULL);

    pthread_join(thread_get, NULL);
    pthread_join(thread_increment, NULL);

    return 1;
}
```

In this example, Bug Finder detects the creation of separate threads with `pthread_create`. The **Data race** defect is raised because the operation `count = count + 1` in the thread with id `thread_increment` conflicts with the operation `c = count` in the thread with id `thread_get`. The variable `count` is accessed in multiple threads without a common protection.

The two conflicting operations are nonatomic. The operation `c = count` is nonatomic on 32-bit targets. See the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server..

Correction — Protect Operations with `pthread_mutex_lock` and `pthread_mutex_unlock` Pair

To prevent concurrent access on the variable `count`, protect operations on `count` with a critical section. Use the functions `pthread_mutex_lock` and `pthread_mutex_unlock` to implement the critical section.

```
#include <pthread.h>

pthread_mutex_t count_mutex;
long long count;


void* increment_count(void* args)
{
    pthread_mutex_lock(&count_mutex);
    count = count + 1;
    pthread_mutex_unlock(&count_mutex);
    return NULL;
}

void* set_count(void *args)
{
    long long c;
    pthread_mutex_lock(&count_mutex);
    c = count;
    pthread_mutex_unlock(&count_mutex);
    return NULL;
}

int main(void)
{
    pthread_t thread_increment;
    pthread_t thread_get;
```

```
    pthread_create(&thread_increment, NULL, increment_count, NULL);
    pthread_create(&thread_get, NULL, set_count, NULL);

    pthread_join(thread_get, NULL);
    pthread_join(thread_increment, NULL);

    return 1;
}
```

Check Information

Group: Rule 50. POSIX (POS)

See Also

External Websites

POS49-C

Introduced in R2019a

CERT C: Rule POS51-C

Avoid deadlock with POSIX threads by locking in predefined order

Description

Rule Definition

Avoid deadlock with POSIX threads by locking in predefined order.

Examples

Deadlock

Description

Deadlock occurs when multiple tasks are stuck in their critical sections (CS) because:

- Each CS waits for another CS to end.
- The critical sections (CS) form a closed cycle. For example:
  - CS #1 waits for CS #2 to end, and CS #2 waits for CS #1 to end.
  - CS #1 waits for CS #2 to end, CS #2 waits for CS #3 to end and CS #3 waits for CS #1 to end.

Polyspace expects critical sections of code to follow a specific format. A critical section lies between a call to a lock function and a call to an unlock function. When a task `my_task` calls a lock function `my_lock`, other tasks calling `my_lock` must wait until `my_task` calls the corresponding unlock function. Both lock and unlock functions must have the form `void func(void)`.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**.

Risk

Each task waits for a critical section in another task to end and is unable to proceed. The program can freeze indefinitely.

Fix

The fix depends on the root cause of the defect. You can try to break the cyclic order between the tasks in one of these ways:

- Write down all critical sections involved in the deadlock in a certain sequence. Whenever you call the lock functions of the critical sections within a task, respect the order in that sequence. See an example below.
- If one of the critical sections involved in a deadlock occurs in an interrupt, try to disable all interrupts during critical sections in all tasks. See `Disabling all interrupts (-routine-disable-interrupts -routine-enable-interrupts)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Reviewing this defect is an opportunity to check if all operations in your critical section are really meant to be executed as an atomic block. It is a good practice to keep critical sections at a bare minimum.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Deadlock with Two Tasks

```
void task1(void);
void task2(void);

int var;
void perform_task_cycle(void) {
 var++;
}

void begin_critical_section_1(void);
void end_critical_section_1(void);

void begin_critical_section_2(void);
```

```
void end_critical_section_2(void);

void task1() {
 while(1) {
    begin_critical_section_1();
    begin_critical_section_2();
    perform_task_cycle();
    end_critical_section_2();
    end_critical_section_1();
 }
}

void task2() {
 while(1) {
    begin_critical_section_2();
    begin_critical_section_1();
    perform_task_cycle();
    end_critical_section_1();
    end_critical_section_2();
 }
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	Specification	
Configure multitasking manually	☑	

Entry points	`task1`
	
	`task2`	

Critical section details	**Starting routine**	**Ending routine**
	`begin_critical_section_1`	`end_critical_section_1`
	`begin_critical_section_2`	`end_critical_section_2`

A **Deadlock** occurs because the instructions can execute in the following sequence:

1. `task1` calls `begin_critical_section_1`.
2. `task2` calls `begin_critical_section_2`.

3. `task1` reaches the instruction `begin_critical_section_2();`. Since `task2` has already called `begin_critical_section_2`, `task1` waits for `task2` to call `end_critical_section_2`.
4. `task2` reaches the instruction `begin_critical_section_1();`. Since `task1` has already called `begin_critical_section_1`, `task2` waits for `task1` to call `end_critical_section_1`.

Correction-Follow Same Locking Sequence in Both Tasks

One possible correction is to follow the same sequence of calls to lock and unlock functions in both `task1` and `task2`.

```
void task1(void);
void task2(void);
void perform_task_cycle(void);

void begin_critical_section_1(void);
void end_critical_section_1(void);

void begin_critical_section_2(void);
void end_critical_section_2(void);

void task1() {
 while(1) {
    begin_critical_section_1();
    begin_critical_section_2();
    perform_task_cycle();
    end_critical_section_2();
    end_critical_section_1();
 }
}

void task2() {
 while(1) {
    begin_critical_section_1();
    begin_critical_section_2();
    perform_task_cycle();
    end_critical_section_2();
    end_critical_section_1();
 }
}
```

Example - Deadlock with More Than Two Tasks

```
int var;
void performTaskCycle() {
 var++;
}

void lock1(void);
void lock2(void);
void lock3(void);


void unlock1(void);
void unlock2(void);
void unlock3(void);

void task1() {
 while(1) {
    lock1();
    lock2();
    performTaskCycle();
    unlock2();
    unlock1();
 }
}

void task2() {
 while(1) {
    lock2();
    lock3();
    performTaskCycle();
    unlock3();
    unlock2();
 }
}

void task3() {
 while(1) {
    lock3();
    lock1();
    performTaskCycle();
```

```
    unlock1();
    unlock3();
 }
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	Specification	
Configure multitasking manually	☑	

Entry points	`task1`
	`task2`
	`task3`	

Critical section details	**Starting routine**	**Ending routine**
	`lock1`	`unlock1`
	`lock2`	`unlock2`
	`lock3`	`unlock3`

A **Deadlock** occurs because the instructions can execute in the following sequence:

1. `task1` calls `lock1`.
2. `task2` calls `lock2`.
3. `task3` calls `lock3`.
4. `task1` reaches the instruction `lock2();`. Since `task2` has already called `lock2`, `task1` waits for call to `unlock2`.
5. `task2` reaches the instruction `lock3();`. Since `task3` has already called `lock3`, `task2` waits for call to `unlock3`.
6. `task3` reaches the instruction `lock1();`. Since `task1` has already called `lock1`, `task3` waits for call to `unlock1`.

Correction — Break Cyclic Order

To break the cyclic order between critical sections, note every lock function in your code in a certain sequence, for example:

1. `lock1`

2. `lock2`
3. `lock3`

If you use more than one lock function in a task, use them in the order in which they appear in the sequence. For example, you can use `lock1` followed by `lock2` but not `lock2` followed by `lock1`.

```
int var;
void performTaskCycle() {
 var++;
}

void lock1(void);
void lock2(void);
void lock3(void);

void unlock1(void);
void unlock2(void);
void unlock3(void);

void task1() {
 while(1) {
    lock1();
    lock2();
    performTaskCycle();
    unlock2();
    unlock1();
 }
}

void task2() {
 while(1) {
    lock2();
    lock3();
    performTaskCycle();
    unlock3();
    unlock2();
 }
}

void task3() {
```

```
 while(1) {
    lock1();
    lock3();
    performTaskCycle();
    unlock3();
    unlock1();
 }
}
```

Check Information

Group: Rule 50. POSIX (POS)

See Also

External Websites

POS51-C

Introduced in R2019a

CERT C: Rule POS52-C

Do not perform operations that can block while holding a POSIX lock

Description

Rule Definition

Do not perform operations that can block while holding a POSIX lock.

Examples

Blocking operation while holding lock

Description

Blocking operation while holding lock occurs when a task (thread) performs a potentially lengthy operation while holding a lock.

The checker considers calls to these functions as potentially lengthy:

- Functions that access a network such as `recv`
- System call functions such as `fork`, `pipe` and `system`
- Functions for I/O operations such as `getchar` and `scanf`
- File handling functions such as `fopen`, `remove` and `lstat`
- Directory manipulation functions such as `mkdir` and `rmdir`

The checker automatically detects certain primitives that hold and release a lock, for instance, `pthread_mutex_lock` and `pthread_mutex_unlock`. For the full list of primitives that are automatically detected, see the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

If a thread performs a lengthy operation when holding a lock, other threads that use the lock have to wait for the lock to be available. As a result, system performance can slow down or deadlocks can occur.

Fix

Perform the blocking operation before holding the lock or after releasing the lock.

Some functions detected by this checker can be called in a way that does not make them potentially lengthy. For instance, the function `recv` can be called with the parameter `O_NONBLOCK` which causes the call to fail if no message is available. When called with this parameter, `recv` does not wait for a message to become available.

Example - Network I/O Operations with `recv` While Holding Lock

```
#include <pthread.h>
#include <sys/socket.h>

pthread_mutexattr_t attr;
pthread_mutex_t mutex;

void thread_foo(void *ptr) {
  unsigned int num;
  int result;
  int sock;

  /* sock is a connected TCP socket */

  if ((result = pthread_mutex_lock(&mutex)) != 0) {
    /* Handle Error */
  }

  if ((result = recv(sock, (void *)&num, sizeof(unsigned int), 0)) < 0) {
    /* Handle Error */
  }

  /* ... */

  if ((result = pthread_mutex_unlock(&mutex)) != 0) {
    /* Handle Error */
  }
}
```

```
int main() {
  pthread_t thread;
  int result;

  if ((result = pthread_mutexattr_settype(
      &attr, PTHREAD_MUTEX_ERRORCHECK)) != 0) {
    /* Handle Error */
  }

  if ((result = pthread_mutex_init(&mutex, &attr)) != 0) {
    /* Handle Error */
  }

  if (pthread_create(&thread, NULL,(void*(*)(void*))& thread_foo, NULL) != 0) {
    /* Handle Error */
  }

  /* ... */

  pthread_join(thread, NULL);

  if ((result = pthread_mutex_destroy(&mutex)) != 0) {
    /* Handle Error */
  }

  return 0;
}
```

In this example, in each thread created with `pthread_create`, the function `thread_foo` performs a network I/O operation with `recv` after acquiring a lock with `pthread_mutex_lock`. Other threads using the same lock variable `mutex` have to wait for the operation to complete and the lock to become available.

Correction — Perform Blocking Operation Before Acquiring Lock

One possible correction is to call `recv` before acquiring the lock.

```
#include <pthread.h>
#include <sys/socket.h>

pthread_mutexattr_t attr;
pthread_mutex_t mutex;
```

```
void thread_foo(void *ptr) {
  unsigned int num;
  int result;
  int sock;

  /* sock is a connected TCP socket */
  if ((result = recv(sock, (void *)&num, sizeof(unsigned int), 0)) < 0) {
    /* Handle Error */
  }

  if ((result = pthread_mutex_lock(&mutex)) != 0) {
    /* Handle Error */
  }

    /* ... */

  if ((result = pthread_mutex_unlock(&mutex)) != 0) {
    /* Handle Error */
  }
}

int main() {
  pthread_t thread;
  int result;

  if ((result = pthread_mutexattr_settype(
      &attr, PTHREAD_MUTEX_ERRORCHECK)) != 0) {
    /* Handle Error */
  }

  if ((result = pthread_mutex_init(&mutex, &attr)) != 0) {
    /* Handle Error */
  }

  if (pthread_create(&thread, NULL,(void*(*)(void*))& thread_foo, NULL) != 0) {
    /* Handle Error */
  }

  /* ... */

  pthread_join(thread, NULL);

  if ((result = pthread_mutex_destroy(&mutex)) != 0) {
    /* Handle Error */
```

```
  }

  return 0;
}
```

Check Information

Group: Rule 50. POSIX (POS)

See Also

External Websites

POS52-C

Introduced in R2019a

CERT C: Rule POS54-C

Detect and handle POSIX library errors

Description

Rule Definition

Detect and handle POSIX library errors.

Examples

Returned value of a sensitive function not checked

Description

Returned value of a sensitive function not checked occurs when you call sensitive standard functions, but you:

- Ignore the return value.
- Use an output or a return value without testing the validity of the return value.

For this defect, two type of functions are considered: ***sensitive*** and ***critical sensitive***.

A ***sensitive*** function is a standard function that can encounter:

- Exhausted system resources (for example, when allocating resources)
- Changed privileges or permissions
- Tainted sources when reading, writing, or converting data from external sources
- Unsupported features despite an existing API

A ***critical sensitive*** function is a sensitive function that performs one of these critical or vulnerable tasks:

- Set privileges (for example, `setuid`)
- Create a jail (for example, `chroot`)
- Create a process (for example, `fork`)
- Create a thread (for example, `pthread_create`)
- Lock or unlock mutex (for example, `pthread_mutex_lock`)
- Lock or unlock memory segments (for example, `mlock`)

Risk

If you do not check the return value of functions that perform sensitive or critical sensitive tasks, your program can behave unexpectedly. Errors from these functions can propagate throughout the program causing incorrect output, security vulnerabilities, and possibly system failures.

Fix

Before continuing with the program, test the return value of *critical sensitive* functions.

For *sensitive functions*, you can explicitly ignore a return value by casting the function to `void`. Polyspace does not raise this defect for sensitive functions cast to void. This resolution is not accepted for *critical sensitive functions* because they perform more vulnerable tasks.

Example - Sensitive Function Return Ignored

```
#include <pthread.h>

void initialize() {
    pthread_attr_t attr;

    pthread_attr_init(&attr);
}
```

This example shows a call to the sensitive function `pthread_attr_init`. The return value of `pthread_attr_init` is ignored, causing a defect.

Correction — Cast Function to `(void)`

One possible correction is to cast the function to void. This fix informs Polyspace and any reviewers that you are explicitly ignoring the return value of the sensitive function.

```
#include <pthread.h>

void initialize() {
    pthread_attr_t attr;

    (void)pthread_attr_init(&attr);
}
```

Correction — Test Return Value

One possible correction is to test the return value of `pthread_attr_init` to check for errors.

```
#include <pthread.h>
#include <stdlib.h>
#define fatal_error() abort()

void initialize() {
    pthread_attr_t attr;
    int result;

    result = pthread_attr_init(&attr);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }
}
```

Example - Critical Function Return Ignored

```
#include <pthread.h>
extern void *start_routine(void *);

void returnnotchecked() {
    pthread_t thread_id;
    pthread_attr_t attr;
    void *res;

    (void)pthread_attr_init(&attr);
    (void)pthread_create(&thread_id, &attr, &start_routine, ((void *)0));
    pthread_join(thread_id,  &res);
}
```

In this example, two critical functions are called: `pthread_create` and `pthread_join`. The return value of the `pthread_create` is ignored by casting to void, but because

`pthread_create` is a critical function (not just a sensitive function), Polyspace does not ignore this *Return value of a sensitive function not checked* defect. The other critical function, `pthread_join`, returns value that is ignored implicitly. `pthread_join` uses the return value of `pthread_create`, which was not checked.

Correction — Test the Return Value of Critical Functions

The correction for this defect is to check the return value of these critical functions to verify the function performed as expected.

```
#include <pthread.h>
#include <stdlib.h>
#define fatal_error() abort()

extern void *start_routine(void *);

void returnnotchecked() {
    pthread_t thread_id;
    pthread_attr_t attr;
    void *res;
    int result;

    (void)pthread_attr_init(&attr);
    result = pthread_create(&thread_id, &attr, &start_routine, NULL);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }

    result = pthread_join(thread_id,  &res);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }
}
```

Check Information

Group: Rule 50. POSIX (POS)

See Also

External Websites

POS54-C

Introduced in R2019a

Rule 51. Microsoft Windows (WIN)

CERT C: Rule WIN30-C

Properly pair allocation and deallocation functions

Description

Rule Definition

Properly pair allocation and deallocation functions.

Examples

Mismatched alloc/dealloc functions on Windows

Description

Mismatched alloc/dealloc functions on Windows occurs when you use a Windows deallocation function that is not properly paired to its corresponding allocation function.

Risk

Deallocating memory with a function that does not match the allocation function can cause memory corruption or undefined behavior. If you are using an older version of Windows, the improper function can also cause compatibility issues with newer versions.

Fix

Properly pair your allocation and deallocation functions according to the functions listed in this table.

Allocation Function	Deallocation Function
`malloc()`	`free()`
`realloc()`	`free()`
`calloc()`	`free()`

Allocation Function	Deallocation Function
_aligned_malloc()	_aligned_free()
_aligned_offset_malloc()	_aligned_free()
_aligned_realloc()	_aligned_free()
_aligned_offset_realloc()	_aligned_free()
_aligned_recalloc()	_aligned_free()
_aligned_offset_recalloc()	_aligned_free()
_malloca()	_freea()
LocalAlloc()	LocalFree()
LocalReAlloc()	LocalFree()
GlobalAlloc()	GlobalFree()
GlobalReAlloc()	GlobalFree()
VirtualAlloc()	VirtualFree()
VirtualAllocEx()	VirtualFreeEx()
VirtualAllocExNuma()	VirtualFreeEx()
HeapAlloc()	HeapFree()
HeapReAlloc()	HeapFree()

Example - Memory Deallocated with Incorrect Function

```
#ifdef _WIN32_
#include <windows.h>
#else
#define _WIN32_
typedef void *HANDLE;
typedef HANDLE HGLOBAL;
typedef HANDLE HLOCAL;
typedef unsigned int UINT;
extern HLOCAL LocalAlloc(UINT uFlags, UINT uBytes);
extern HLOCAL LocalFree(HLOCAL hMem);
extern HGLOBAL GlobalFree(HGLOBAL hMem);
#endif

#define SIZE9 9
```

```
void func(void)
{
    /* Memory allocation */
    HLOCAL p = LocalAlloc(0x0000, SIZE9);

    if (p) {
        /* Memory deallocation. */
        GlobalFree(p);

    }
}
```

In this example, memory is allocated with `LocallAlloc()`. The program then erroneously uses `GlobalFree()` to deallocate the memory.

Correction — Properly Pair Windows Allocation and Deallocation Functions

When you allocate memory with `LocalAllocate()`, use `LocalFree()` to deallocate the memory.

```
#ifdef _WIN32_
#include <windows.h>
#else
#define _WIN32_
typedef void *HANDLE;
typedef HANDLE HGLOBAL;
typedef HANDLE HLOCAL;
typedef unsigned int UINT;
extern HLOCAL LocalAlloc(UINT uFlags, UINT uBytes);
extern HLOCAL LocalFree(HLOCAL hMem);
extern HGLOBAL GlobalFree(HGLOBAL hMem);
#endif

#define SIZE9 9
void func(void)
{
    /* Memory allocation */
    HLOCAL p = LocalAlloc(0x0000, SIZE9);
    if (p) {
        /* Memory deallocation. */
        LocalFree(p);
    }
}
```

Check Information

Group: Rule 51. Microsoft Windows (WIN)

See Also

External Websites

WIN30-C

Introduced in R2019a

Rec. 01. Preprocessor (PRE)

CERT C: Rec. PRE00-C

Prefer inline or static functions to function-like macros

Description

Rule Definition

Prefer inline or static functions to function-like macros.

Examples

Use of function-like macro instead of function

Description

The issue occurs when you use a function-like macro instead of a function when the two are interchangeable.

Polyspace considers all function-like macro definitions.

Risk

In most circumstances, use functions instead of macros. Functions perform argument type-checking and evaluate their arguments once, avoiding problems with potential multiple side effects.

Check Information

Group: Rec. 01. Preprocessor (PRE)

See Also

External Websites

PRE00-C

Introduced in R2019a

CERT C: Rec. PRE01-C

Use parentheses within macros around parameter names

Description

Rule Definition

Use parentheses within macros around parameter names.

Examples

Expanded macro parameters not enclosed in parentheses

Description

The issue occurs when expressions resulting from the expansion of macro parameters are not enclosed in parentheses.

Risk

If you do not use parentheses, then it is possible that operator precedence does not give the results that you want when macro substitution occurs.

If you are not using a macro parameter as an expression, then the parentheses are not necessary because no operators are involved in the macro.

Example - Macro Expressions

```
#define mac1(x, y) (x * y)
#define mac2(x, y) ((x) * (y))

void foo(void){
    int r;

    r = mac1(1 + 2, 3 + 4);       /* Non-compliant */
    r = mac1((1 + 2), (3 + 4));   /* Compliant */
```

```
    r = mac2(1 + 2, 3 + 4);       /* Compliant */
}
```

In this example, `mac1` and `mac2` are two defined macro expressions. The definition of `mac1` does not enclose the arguments in parentheses. In line 7, the macro expands to `r = (1 + 2 * 3 + 4);` This expression can be `(1 + (2 * 3) + 4)` or `(1 + 2) * (3 + 4)`. However, without parentheses, the program does not know the intended expression. Line 8 uses parentheses, so the line expands to `(1 + 2) * (3 + 4)`. This macro expression is compliant.

The definition of `mac2` does enclose the argument in parentheses. Line 10 (the same macro arguments in line 7) expands to `(1 + 2) * (3 + 4)`. This macro and macro expression are compliant.

Check Information

Group: Rec. 01. Preprocessor (PRE)

See Also

External Websites

PRE01-C

Introduced in R2019a

CERT C: Rec. PRE06-C

Enclose header files in an inclusion guard

Description

Rule Definition

Enclose header files in an inclusion guard.

Examples

Contents of header file not guarded from multiple inclusions

Description

The issue occurs when you do not take precautions order to prevent the contents of a header file being included more than once.

If you include a header file whose contents are not guarded from multiple inclusion, the analysis raises a violation of this directive. The violation is shown at the beginning of the header file.

You can guard the contents of a header file from multiple inclusion by using one of the following methods:

```
<start-of-file>
#ifndef <control macro>
#define <control macro>
    /* Contents of file */
#endif
<end-of-file>
```

or

```
<start-of-file>
```

```
#ifdef <control macro>
#error ...
#else
#define <control macro>
    /* Contents of file */
#endif
<end-of-file>
```

Unless you use one of these methods, Polyspace flags the header file inclusion as noncompliant.

Risk

When a translation unit contains a complex hierarchy of nested header files, it is possible for a particular header file to be included more than once, leading to confusion. If this multiple inclusion produces multiple or conflicting definitions, then your program can have undefined or erroneous behavior.

For instance, suppose that a header file contains:

```
#ifdef _WIN64
   int env_var;
#elseif
   long int env_var;
#endif
```

If the header file is contained in two inclusion paths, one that defines the macro `_WIN64` and another that undefines it, you can have conflicting definitions of `env_var`.

Example - Code After Macro Guard

```
#ifndef  __MY_MACRO__
#define __MY_MACRO__
    void func(void);
#endif
void func2(void);
```

If a header file contains this code, it is noncompliant because the macro guard does not cover the entire content of the header file. The line `void func2(void)` is outside the guard.

Note You can have comments outside the macro guard.

Example - Code Before Macro Guard

```
void func(void);
#ifndef  __MY_MACRO__
#define __MY_MACRO__
    void func2(void);
#endif
```

If a header file contains this code, it is noncompliant because the macro guard does not cover the entire content of the header file. The line `void func(void)` is outside the guard.

Note You can have comments outside the macro guard.

Example - Mismatch in Macro Guard

```
#ifndef  __MY_MACRO__
#define __MY_MARCO__
    void func(void);
    void func2(void);
#endif
```

If a header file contains this code, it is noncompliant because the macro name in the `#ifndef` statement is different from the name in the following `#define` statement.

Check Information

Group: Rec. 01. Preprocessor (PRE)

See Also

External Websites

PRE06-C

Introduced in R2019a

CERT C: Rec. PRE07-C

Avoid using repeated question marks

Description

Rule Definition

Avoid using repeated question marks.

Examples

Use of trigraphs

Description

The issue occurs when you use trigraphs in your code.

The Polyspace analysis converts trigraphs to the equivalent character for the defect analysis. However, Polyspace also raises a MISRA violation.

The standard requires that trigraphs must be transformed *before* comments are removed during preprocessing. Therefore, Polyspace raises a violation of this rule even if a trigraph appears in code comments.

Risk

You denote trigraphs with two question marks followed by a specific third character (for instance,`'??-'` represents a `'~'` (tilde) character and `'??)'` represents a `']'`). These trigraphs can cause accidental confusion with other uses of two question marks.

Note Digraphs (`<: :>`, `<% %>`, `%:`, `%:%:`) are permitted because they are tokens.

Check Information

Group: Rec. 01. Preprocessor (PRE)

See Also

External Websites

PRE07-C

Introduced in R2019a

CERT C: Rec. PRE09-C

Do not replace secure functions with deprecated or obsolescent functions

Description

Rule Definition

Do not replace secure functions with deprecated or obsolescent functions.

Examples

Use of dangerous standard function

Description

The **Use of dangerous standard function** check highlights uses of functions that are inherently dangerous or potentially dangerous given certain circumstances. The following table lists possibly dangerous functions, the risks of using each function, and what function to use instead.

Dangerous Function	Risk Level	Safer Function
`gets`	Inherently dangerous — You cannot control the length of input from the console.	`fgets`
`cin`	Inherently dangerous — You cannot control the length of input from the console.	Avoid or prefaces calls to `cin` with `cin.width`.
`strcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`strncpy`

Dangerous Function	Risk Level	Safer Function
`stpcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`stpncpy`
`lstrcpy` or `StrCpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`StringCbCopy`, `StringCchCopy`, `strncpy`, `strcpy_s`, or `strlcpy`
`strcat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`strncat`, `strlcat`, or `strcat_s`
`lstrcat` or `StrCat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`StringCbCat`, `StringCchCat`, `strncay`, `strcat_s`, or `strlcat`
`wcpcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`wcpncpy`
`wcscat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`wcsncat`, `wcslcat`, or `wcncat_s`
`wcscpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`wcsncpy`
`sprintf`	Possibly dangerous — If the output length depends on unknown lengths or values, buffer overflow can occur.	`snprintf`

Dangerous Function	Risk Level	Safer Function
`vsprintf`	Possibly dangerous — If the output length depends on unknown lengths or values, buffer overflow can occur.	`vsnprintf`

Risk

These functions can cause buffer overflow, which attackers can use to infiltrate your program.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Using `sprintf`

```
#include <stdio.h>
#include <string.h>
#include <iostream>

#define BUFF_SIZE 128


int dangerous_func(char *str)
{
    char dst[BUFF_SIZE];
    int r = 0;

    if (sprintf(dst, "%s", str) == 1)
    {
        r += 1;
        dst[BUFF_SIZE-1] = '\0';
    }
```

```
    return r;
}
```

This example function uses `sprintf` to copy the string `str` to `dst`. However, if `str` is larger than the buffer, `sprintf` can cause buffer overflow.

Correction — Use `snprintf` with Buffer Size

One possible correction is to use `snprintf` instead and specify a buffer size.

```
#include <stdio.h>
#include <string.h>
#include <iostream>

#define BUFF_SIZE 128


int dangerous_func(char *str)
{
    char dst[BUFF_SIZE];
    int r = 0;

    if (snprintf(dst, sizeof(dst), "%s", str) == 1)
    {
        r += 1;
        dst[BUFF_SIZE-1] = '\0';
    }

    return r;
}
```

Check Information

Group: Rec. 01. Preprocessor (PRE)

See Also

External Websites

PRE09-C

Introduced in R2019a

Rec. 02. Declarations and Initialization (DCL)

CERT C: Rec. DCL01-C

Do not reuse variable names in subscopes

Description

Rule Definition

Do not reuse variable names in subscopes.

Examples

Variable shadowing

Description

Variable shadowing occurs when a variable hides another variable of the same name in an outer scope.

For instance, if a local variable has the same name as a global variable, the local variable hides the global variable during its lifetime.

Risk

When two variables with the same name exist in an inner and outer scope, any reference to the variable name uses the variable in the inner scope. However, a developer or reviewer might incorrectly expect that the variable in the outer scope was used.

Fix

The fix depends on the root cause of the defect. For instance, suppose you refactor a function such that you use a local static variable in place of a global variable. In this case, the global variable is redundant and you can remove its declaration. Alternatively, if you are not sure if the global variable is used elsewhere, you can modify the name of the local static variable and all references within the function.

If the shadowing is intended and you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Variable Shadowing Error

```
#include <stdio.h>

int fact[5]={1,2,6,24,120};

int factorial(int n)
 {
  int fact=1;
  /*Defect: Local variable hides global array with same name */

  for(int i=1;i<=n;i++)
    fact*=i;

  return(fact);
 }
```

Inside the `factorial` function, the integer variable `fact` hides the global integer array `fact`.

Correction — Change Variable Name

One possible correction is to change the name of one of the variables, preferably the one with more local scope.

```
#include <stdio.h>

int fact[5]={1,2,6,24,120};

int factorial(int n)
 {
  /* Fix: Change name of local variable */
  int f=1;

  for(int i=1;i<=n;i++)
    f*=i;

  return(f);
 }
```

Check Information

Group: Rec. 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL01-C

Introduced in R2019a

CERT C: Rec. DCL02-C

Use visually distinct identifiers

Description

Rule Definition

Use visually distinct identifiers.

Examples

Use of typographically ambiguous identifiers

Description

The issue occurs when you use identifiers in the same name space with overlapping visibility and the identifiers are not typographically unambiguous.

Risk

What “unambiguous” means depends on the alphabet and language in which source code is written. When you use identifiers that are typographically close, you can confuse between them.

For the Latin alphabet as used in English words, at a minimum, the identifiers should not differ by:

- The interchange of a lowercase letter with its uppercase equivalent.
- The presence or absence of the underscore character.
- The interchange of the letter `O` and the digit `0`.
- The interchange of the letter `I` and the digit `1`.
- The interchange of the letter `I` and the letter `l`.
- The interchange of the letter `S` and the digit `5`.

- The interchange of the letter `Z` and the digit `2`.
- The interchange of the letter `n` and the letter `h`.
- The interchange of the letter `B` and the digit `8`.
- The interchange of the letters `rn` and the letter `m`.

Example - Typographically Ambiguous Identifiers

```
void func(void) {
    int id1_numval;
    int id1_num_val;  /* Non-compliant */

    int id2_numval;
    int id2_numVal;   /* Non-compliant */

    int id3_lvalue;
    int id3_Ivalue;   /* Non-compliant */

    int id4_xyz;
    int id4_xy2;      /* Non-compliant */

    int id5_zerO;
    int id5_zer0;     /* Non-compliant */

    int id6_rn;
    int id6_m;        /* Non-compliant */
}
```

In this example, the rule is violated when identifiers that can be confused for each other are used.

Check Information

Group: Rec. 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL02-C

Introduced in R2019a

CERT C: Rec. DCL06-C

Use meaningful symbolic constants to represent literal values

Description

Rule Definition

Use meaningful symbolic constants to represent literal values.

Examples

Hard-coded buffer size

Description

Hard-coded buffer size occurs when you use a numerical value instead of a symbolic constant when declaring a memory buffer such as an array.

Risk

Hard-coded buffer size causes the following issues:

- Hard-coded buffer size increases the likelihood of mistakes and therefore maintenance costs. If a policy change requires developers to change the buffer size, they must change every occurrence of the buffer size in the code.
- Hard-constant constants can be exposed to attack if the code is disclosed.

Fix

Use a symbolic name instead of a hard-coded constant for buffer size. Symbolic names include `const`-qualified variables, `enum` constants, or macros.

`enum` constants are recommended.

- Macros are replaced by their constant values after preprocessing. Therefore, they can expose the loop boundary.
- `enum` constants are known at compilation time. Therefore, compilers can optimize the loops more efficiently.

  `const`-qualified variables are usually known at run time.

Example - Hard-Coded Buffer Size

```
int table[100];

void read(int);

void func(void) {
    for (int i=0; i<100; i++)
        read(table[i]);
}
```

In this example, the size of the array `table` is hard-coded.

Correction — Use Symbolic Name

One possible correction is to replace the hard-coded size with a symbolic name.

```
const int MAX_1 = 100;
#define MAX_2 100
enum { MAX_3 = 100 };

int table_1[MAX_1];
int table_2[MAX_2];
int table_3[MAX_3];

void read(int);

void func(void) {
    for (int i=0; i < MAX_1; i++)
        read(table_1[i]);
    for (int i=0; i < MAX_2; i++)
        read(table_2[i]);
    for (int i=0; i < MAX_3; i++)
        read(table_3[i]);
}
```

Hard-coded loop boundary

Description

Hard-coded loop boundary occurs when you use a numerical value instead of symbolic constant for the boundary of a `for`, `while` or `do-while` loop.

Risk

Hard-coded loop boundary causes the following issues:

- Hard-coded loop boundary makes the code vulnerable to denial of service attacks when the loop involves time-consuming computation or resource allocation.
- Hard-coded loop boundary increases the likelihood of mistakes and maintenance costs. If a policy change requires developers to change the loop boundary, they must change every occurrence of the boundary in the code.

  For instance, the loop boundary is 10000 and represents the maximum number of client connections supported in a network server application. If the server supports more clients, you must change all instances of the loop boundary in your code. Even if the loop boundary occurs once, you have to search for a numerical value of `10000` in your code. The numerical value can occur in places other than the loop boundary. You must browse through those places before you find the loop boundary.

Fix

Use a symbolic name instead of a hard-coded constant for loop boundary. Symbolic names include `const`-qualified variables, `enum` constants or macros.`enum` constants are recommended because:

- Macros are replaced by their constant values after preprocessing. Therefore, they can expose the buffer size.
- `enum` constants are known at compilation time. Therefore, compilers can allocate storage for them more efficiently.

  `const`-qualified variables are usually known at run time.

Example - Hard-Coded Loop Boundary

```
void performOperation(int);

void func(void) {
```

```
    for (int i=0; i<100; i++)
        performOperation(i);
}
```

In this example, the boundary of the `for` loop is hard-coded.

Correction — Use Symbolic Name

One possible correction is to replace the hard-coded loop boundary with a symbolic name.

```
const int MAX_1 = 100;
#define MAX_2 100
enum { MAX_3 = 100 };

void performOperation_1(int);
void performOperation_2(int);
void performOperation_3(int);

void func(void) {
    for (int i=0; i<MAX_1; i++)
        performOperation_1(i);
    for (int i=0; i<MAX_2; i++)
        performOperation_2(i);
    for (int i=0; i<MAX_3; i++)
        performOperation_3(i);
}
```

Check Information

Group: Rec. 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL06-C

Introduced in R2019a

CERT C: Rec. DCL07-C

Include the appropriate type information in function declarators

Description

Rule Definition

Include the appropriate type information in function declarators.

Examples

Cast between function pointers with different types

Description

The issues occurs when you perform a conversion between a pointer to a function and any other type.

Polyspace considers both explicit and implicit casts when checking this rule. However, casts from `NULL` or `(void*)0` do not violate this rule.

Risk

The rule forbids the following two conversions:

- Conversion from a function pointer to any other type. This conversion causes undefined behavior.
- Conversion from a function pointer to another function pointer, if the function pointers have different argument and return types.

  The conversion is forbidden because calling a function through a pointer with incompatible type results in undefined behavior.

Example - Cast between two function pointers

```
typedef void (*fp16) (short n);
typedef void (*fp32) (int n);

#include <stdlib.h>                    /* To obtain macro  NULL */

void func(void) {   /* Exception 1 - Can convert a null pointer
                     * constant into a pointer to a function */
  fp16 fp1 = NULL;                 /* Compliant - exception  */
  fp16 fp2 = (fp16) fp1;           /* Compliant */
  fp32 fp3 = (fp32) fp1;           /* Non-compliant */
  if (fp2 != NULL) {}              /* Compliant - exception  */
  fp16 fp4 = (fp16) 0x8000;        /* Non-compliant - integer to
                                    * function pointer */}
```

In this example, the rule is violated when:

- The pointer `fp1` of type `fp16` is cast to type `fp32`. The function pointer types `fp16` and `fp32` have different argument types.
- An integer is cast to type `fp16`.

The rule is not violated when function pointers `fp1` and `fp2` are cast to `NULL`.

Function declared implicitly

Description

The issue occurs when you declare a function implicitly.

Risk

An implicit declaration occurs when you call a function before declaring or defining it. When you declare a function explicitly before calling it, the compiler can match the argument and return types with the parameter types in the declaration. If an implicit declaration occurs, the compiler makes assumptions about the argument and return types. For instance, it assumes a return type of `int`. The assumptions might not agree with what you expect and cause undesired type conversions.

Example - Function Not Declared Before Call

```
#include <math.h>
```

```
extern double power3 (double val, int exponent);
int getChoice(void);

double func() {
    double res;
    int ch = getChoice();
    if(ch == 0) {
        res = power(2.0, 10);    /* Non-compliant */
    }
    else if( ch==1) {
        res = power2(2.0, 10);   /* Non-compliant */
    }
    else {
        res = power3(2.0, 10);   /* Compliant */
        return res;
    }
}

double power2 (double val, int exponent) {
    return (pow(val, exponent));
}
```

In this example, the rule is violated when a function that is not declared is called in the code. Even if a function definition exists later in the code, the rule violation occurs.

The rule is not violated when the function is declared before it is called in the code. If the function definition exists in another file and is available only during the link phase, you can declare the function in one of the following ways:

- Declare the function with the `extern` keyword in the current file.
- Declare the function in a header file and include the header file in the current file.

Check Information

Group: Rec. 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL07-C

Introduced in R2019a

CERT C: Rec. DCL10-C

Maintain the contract between the writer and caller of variadic functions

Description

Rule Definition

Maintain the contract between the writer and caller of variadic functions.

Examples

Format string specifiers and arguments mismatch

Description

Format string specifiers and arguments mismatch occurs when the format specifiers in the formatted output functions such as `printf` do not match their corresponding arguments. For example, an argument of type `unsigned long` must have a format specification of `%lu`.

Risk

Mismatch between format specifiers and the corresponding arguments result in undefined behavior.

Fix

Make sure that the format specifiers match the corresponding arguments. For instance, in this example, the `%d` specifier does not match the string argument `message` and the `%s` specifier does not match the integer argument `err_number`.

```
const char *message = "License not available";
int err_number = ;-4
printf("Error: %d (error type %s)\n", message, err_number);
```

Switching the two format specifiers fixes the issue. See the specifications for the printf function for more information about format specifiers.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Printing a Float

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;

    printf("%d\n", fst);
}
```

In the `printf` statement, the format specifier, `%d`, does not match the data type of `fst`.

Correction — Use an Unsigned Long Format Specifier

One possible correction is to use the `%lu` format specifier. This specifier matches the `unsigned` integer type and `long` size of `fst`.

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;

    printf("%lu\n", fst);
}
```

Correction — Use an Integer Argument

One possible correction is to change the argument to match the format specifier. Convert `fst` to an integer to match the format specifier and print the value `1`.

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;
```

```
    printf("%d\n", (int)fst);
}
```

Check Information

Group: Rec. 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL10-C

Introduced in R2019a

CERT C: Rec. DCL11-C

Understand the type issues associated with variadic functions

Description

Rule Definition

Understand the type issues associated with variadic functions.

Examples

Format string specifiers and arguments mismatch

Description

Format string specifiers and arguments mismatch occurs when the format specifiers in the formatted output functions such as `printf` do not match their corresponding arguments. For example, an argument of type `unsigned long` must have a format specification of `%lu`.

Risk

Mismatch between format specifiers and the corresponding arguments result in undefined behavior.

Fix

Make sure that the format specifiers match the corresponding arguments. For instance, in this example, the `%d` specifier does not match the string argument `message` and the `%s` specifier does not match the integer argument `err_number`.

```
const char *message = "License not available";
int err_number = ;-4
printf("Error: %d (error type %s)\n", message, err_number);
```

Switching the two format specifiers fixes the issue. See the specifications for the printf function for more information about format specifiers.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Printing a Float

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;

    printf("%d\n", fst);
}
```

In the `printf` statement, the format specifier, `%d`, does not match the data type of `fst`.

Correction — Use an Unsigned Long Format Specifier

One possible correction is to use the `%lu` format specifier. This specifier matches the `unsigned` integer type and `long` size of `fst`.

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;

    printf("%lu\n", fst);
}
```

Correction — Use an Integer Argument

One possible correction is to change the argument to match the format specifier. Convert `fst` to an integer to match the format specifier and print the value `1`.

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;
```

```
    printf("%d\n", (int)fst);
}
```

Check Information

Group: Rec. 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL11-C

Introduced in R2019a

CERT C: Rec. DCL12-C

Implement abstract data types using opaque types

Description

Rule Definition

Implement abstract data types using opaque types.

Examples

Structure or union object implementation visible in file where pointer to this object is not dereferenced

Description

The issue occurs when a pointer to a structure or union is never dereferenced within a translation unit, but the implementation of the object is not hidden.

If a structure or union is defined in a file or a header file included in the file, a pointer to this structure or union declared but the pointer never dereferenced in the file, the checker flags a coding rule violation. The structure or union definition should not be visible to this file.

If you see a violation of this rule on a structure definition, identify if you have defined a pointer to the structure in the same file or in a header file included in the file. Then check if you dereference the pointer anywhere in the file. If you do not dereference the pointer, the structure definition should be hidden from this file and included header files.

`file.h`: Contains structure implementation.

```
#ifndef TYPE_GUARD
#define TYPE_GUARD

typedef struct  {
```

```
  int a;
} myStruct;

#endif
```

`file.c`: Includes `file.h` but does not dereference structure.

```
#include "file.h"

myStruct* getObj(void);
void useObj(myStruct*);

void func() {
  myStruct *sPtr = getObj();
  useObj(sPtr);
}
```

In this example, the pointer to the type `myStruct` is not dereferenced. The pointer is simply obtained from the `getObj` function and passed to the `useObj` function.

The implementation of `myStruct` is visible in the translation unit consisting of `file.c` and `file.h`.

One possible correction is to define an opaque data type in the header file `file.h`. The opaque data type `ptrMyStruct` points to the `myStruct` structure without revealing what the structure contains. The structure `myStruct` itself can be defined in a separate translation unit, in this case, consisting of the file `file2.c`. The common header file `file.h` must be included in both `file.c` and `file2.c` for linking the structure definition to the opaque type definition.

`file.h`: Does not contain structure implementation.

```
#ifndef TYPE_GUARD
#define TYPE_GUARD

typedef struct myStruct *ptrMyStruct;

ptrMyStruct getObj(void);
void useObj(ptrMyStruct);

#endif
```

`file.c`: Includes `file.h` but does not dereference structure.

```
#include "file.h"

void func() {
  ptrMyStruct sPtr = getObj();
  useObj(sPtr);
}
```

`file2.c`: Includes `file.h` and dereferences structure.

```
#include "file.h"

struct myStruct {
  int a;
};

void useObj(ptrMyStruct ptr) {
    (ptr->a)++;
}
```

Risk

If a pointer to a structure or union is not dereferenced in a file, the implementation details of the structure or union need not be available in the translation unit for the file. You can hide the implementation details such as structure members and protect them from unintentional changes.

Define an opaque type that can be referenced via pointers but whose contents cannot be accessed.

Example - Object Implementation Revealed

`file.h`: Contains structure implementation.

```
#ifndef TYPE_GUARD
#define TYPE_GUARD

typedef struct  {
  int a;
} myStruct;

#endif
```

`file.c`: Includes `file.h` but does not dereference structure.

```
#include "file.h"

myStruct* getObj(void);
void useObj(myStruct*);

void func() {
  myStruct *sPtr = getObj();
  useObj(sPtr);
}
```

In this example, the pointer to the type `myStruct` is not dereferenced. The pointer is simply obtained from the `getObj` function and passed to the `useObj` function.

The implementation of `myStruct` is visible in the translation unit consisting of `file.c` and `file.h`.

Correction — Define Opaque Type

One possible correction is to define an opaque data type in the header file `file.h`. The opaque data type `ptrMyStruct` points to the `myStruct` structure without revealing what the structure contains. The structure `myStruct` itself can be defined in a separate translation unit, in this case, consisting of the file `file2.c`. The common header file `file.h` must be included in both `file.c` and `file2.c` for linking the structure definition to the opaque type definition.

`file.h`: Does not contain structure implementation.

```
#ifndef TYPE_GUARD
#define TYPE_GUARD

typedef struct myStruct *ptrMyStruct;

ptrMyStruct getObj(void);
void useObj(ptrMyStruct);

#endif
```

`file.c`: Includes `file.h` but does not dereference structure.

```
#include "file.h"

void func() {
  ptrMyStruct sPtr = getObj();
  useObj(sPtr);
}
```

`file2.c`: Includes `file.h` and dereferences structure.

```
#include "file.h"

struct myStruct {
  int a;
};

void useObj(ptrMyStruct ptr) {
    (ptr->a)++;
}
```

Check Information

Group: Rec. 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL12-C

Introduced in R2019a

CERT C: Rec. DCL13-C

Declare function parameters that are pointers to values not changed by the function as const

Description

Rule Definition

Declare function parameters that are pointers to values not changed by the function as const.

Examples

Pointer to non-`const` qualified function parameter

Description

The rule checker flags a pointer to a non-`const` function parameter if the pointer does not modify the addressed object. The assumption is that the pointer is not meant to modify the object and so must point to a `const`-qualified type.

Risk

This rule ensures that you do not inadvertently use pointers to modify objects.

Example - Pointer That Should Point to `const`-Qualified Types

```
#include <string.h>

typedef unsigned short uint16_t;

uint16_t ptr_ex(uint16_t *p) {      /* Non-compliant */
    return *p;
}

char last_char(char * const s){     /* Non-compliant */
```

```
    return s[strlen(s) - 1u];
}

uint16_t first(uint16_t a[5]){      /* Non-compliant */
    return a[0];
}
```

This example shows three different noncompliant pointer parameters.

- In the `ptr_ex` function, `p` does not modify an object. However, the type to which `p` points is not `const`-qualified, so it is noncompliant.
- In `last_char`, the pointer `s` is `const`-qualified but the type it points to is not. This parameter is noncompliant because `s` does not modify an object.
- The function `first` does not modify the elements of the array `a`. However, the element type is not `const`-qualified, so `a` is also noncompliant.

Correction — Use `const` Keywords

One possible correction is to add `const` qualifiers to the definitions.

```
#include <string.h>

typedef unsigned short uint16_t;

uint16_t ptr_ex(const uint16_t *p){     /* Compliant */
    return *p;
}

char last_char(const char * const s){   /* Compliant */
    return s[strlen( s ) - 1u];
}

uint16_t first(const uint16_t a[5]) {   /* Compliant */
    return a[0];
}
```

Check Information

Group: Rec. 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL13-C

Introduced in R2019a

CERT C: Rec. DCL15-C

Declare file-scope objects or functions that do not need external linkage as static

Description

Rule Definition

Declare file-scope objects or functions that do not need external linkage as static.

Examples

Function or object with external linkage referenced in only one translation unit

Description

The rule checker flags:

- Objects that are defined at file scope without the `static` specifier but used only in one file.
- Functions that are defined without the `static` specifier but called only in one file.

If you intend to use the object or function in one file only, declare it static.

Objects that are defined at file scope without the `static` specifier but used only in one file.

Functions that are defined without the `static` specifier but called only in one file.

Polyspace Bug Finder and Polyspace Code Prover check this coding rule differently. The analyses can produce different results.

Risk

Compliance with this rule avoids confusion between your identifier and an identical identifier in another translation unit or library. If you restrict or reduce the visibility of an

object by giving it internal linkage or no linkage, you or someone else is less likely to access the object inadvertently.

Example - Variable with External Linkage Used in One File

Header file:

```
/* file.h */
extern int var;
```

First source file:

```
/* file1.c */
#include "file.h"

int var;    /* Compliant */
int var2;   /* Non compliant */
static int var3; /* Compliant */

void reset(void);

void reset(void) {
    var = 0;
    var2 = 0;
    var3 = 0;
}
```

Second source file:

```
/* file2.c */
#include "file.h"

void increment(int var2);

void increment(int var2) {
    var++;
    var2++;
}
```

In this example:

- The declaration of `var` is compliant because `var` is declared with external linkage and used in multiple files.
- The declaration of `var2` is noncompliant because `var2` is declared with external linkage but used in one file only.

It might appear that `var2` is defined in both files. However, in the second file, `var2` is a parameter with no linkage and is not the same as the `var2` in the first file.

- The declaration of `var3` is compliant because `var3` is declared with internal linkage (with the `static` specifier) and used in one file only.

Example - Function with External Linkage Used in One File

Header file:

```
/* file.h */
extern int var;
extern void increment1 (void);
```

First source file:

```
/* file1.c */
#include "file.h"

int var;

void increment2(void);
static void increment3(void);
void func(void);

void increment2(void) { /* Non compliant */
    var+=2;
}

static void increment3(void) { /* Compliant */
    var+=3;
}

void func(void) {
    increment1();
    increment2();
    increment3();
}
```

Second source file:

```
/* file2.c */
#include "file.h"

void increment1(void) { /* Compliant */
```

```
    var++;
}
```

In this example:

- The definition of `increment1` is compliant because `increment1` is defined with external linkage and called in a different file.
- The declaration of `increment2` is noncompliant because `increment2` is defined with external linkage but called in the same file and nowhere else.
- The declaration of `increment3` is compliant because `increment3` is defined with internal linkage (with the `static` specifier) and called in the same file and nowhere else.

Check Information

Group: Rec. 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL15-C

Introduced in R2019a

CERT C: Rec. DCL16-C

Use 'L,' not 'l,' to indicate a long value

Description

Rule Definition

Use 'L,' not 'l,' to indicate a long value.

Examples

Use of lowercase "l" in literal suffix

Description

The issue occurs when you use the lowercase character “l” in a literal suffix.

Risk

The lowercase character “l” can be confused with the digit “1”. Use the uppercase “L” instead.

Check Information

Group: Rec. 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL16-C

Introduced in R2019a

CERT C: Rec. DCL18-C

Do not begin integer constants with 0 when specifying a decimal value

Description

Rule Definition

Do not begin integer constants with 0 when specifying a decimal value.

Examples

Use of octal constants

Description

If you use octal constants in a macro definition, the rule checker flags the issue even if the macro is not used.

Risk

Octal constants are denoted by a leading zero. Developers can mistake an octal constant as a decimal constant with a redundant leading zero.

Example - Use of octal constants

```
#define CST     021
#define VALUE   010             /* Compliant - constant not used */
#if 010 == 01                   /* Non-Compliant - constant used */
#define CST 021                 /* Non-Compliant - constant not used */
#endif

extern short code[5];
static char* str2 = "abcd\0efg";  /* Compliant */

void main(void) {
    int value1 = 0;              /* Compliant */
```

```
    int value2 = 01;              /* Non-Compliant - decimal 01 */
    int value3 = 1;               /* Compliant */
    int value4 = '\109';          /* Compliant */

    code[1] = 109;                /* Compliant     - decimal 109 */
    code[2] = 100;                /* Compliant     - decimal 100 */
    code[3] = 052;                /* Non-Compliant - decimal 42 */
    code[4] = 071;                /* Non-Compliant - decimal 57 */

    if (value1 != CST) {          /* Non-Compliant - decimal 17 */
        value1 = !(value1 != 0);  /* Compliant */
    }
}
```

In this example, the rule is not violated when octal constants are used to define macros `CST` and `VALUE`. The rule is violated only when the macros are used.

Check Information

Group: Rec. 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL18-C

Introduced in R2019a

CERT C: Rec. DCL19-C

Minimize the scope of variables and functions

Description

Rule Definition

Minimize the scope of variables and functions.

Examples

Function or object declared without `static` specifier and referenced in only one file

Description

The rule checker flags:

- Objects that are defined at file scope without the `static` specifier but used only in one file.
- Functions that are defined without the `static` specifier but called only in one file.

If you intend to use the object or function in one file only, declare it static.

Objects that are defined at file scope without the `static` specifier but used only in one file.

Functions that are defined without the `static` specifier but called only in one file.

Polyspace Bug Finder and Polyspace Code Prover check this coding rule differently. The analyses can produce different results.

Risk

Compliance with this rule avoids confusion between your identifier and an identical identifier in another translation unit or library. If you restrict or reduce the visibility of an

object by giving it internal linkage or no linkage, you or someone else is less likely to access the object inadvertently.

Example - Variable with External Linkage Used in One File

Header file:

```
/* file.h */
extern int var;
```

First source file:

```
/* file1.c */
#include "file.h"

int var;    /* Compliant */
int var2;   /* Non compliant */
static int var3; /* Compliant */

void reset(void);

void reset(void) {
    var = 0;
    var2 = 0;
    var3 = 0;
}
```

Second source file:

```
/* file2.c */
#include "file.h"

void increment(int var2);

void increment(int var2) {
    var++;
    var2++;
}
```

In this example:

- The declaration of `var` is compliant because `var` is declared with external linkage and used in multiple files.
- The declaration of `var2` is noncompliant because `var2` is declared with external linkage but used in one file only.

It might appear that `var2` is defined in both files. However, in the second file, `var2` is a parameter with no linkage and is not the same as the `var2` in the first file.

- The declaration of `var3` is compliant because `var3` is declared with internal linkage (with the `static` specifier) and used in one file only.

Example - Function with External Linkage Used in One File

Header file:

```
/* file.h */
extern int var;
extern void increment1 (void);
```

First source file:

```
/* file1.c */
#include "file.h"

int var;

void increment2(void);
static void increment3(void);
void func(void);

void increment2(void) { /* Non compliant */
    var+=2;
}

static void increment3(void) { /* Compliant */
    var+=3;
}

void func(void) {
    increment1();
    increment2();
    increment3();
}
```

Second source file:

```
/* file2.c */
#include "file.h"

void increment1(void) { /* Compliant */
```

```
    var++;
}
```

In this example:

- The definition of `increment1` is compliant because `increment1` is defined with external linkage and called in a different file.
- The declaration of `increment2` is noncompliant because `increment2` is defined with external linkage but called in the same file and nowhere else.
- The declaration of `increment3` is compliant because `increment3` is defined with internal linkage (with the `static` specifier) and called in the same file and nowhere else.

Object defined beyond necessary scope

Description

The issue occurs when the identifier of an object only appears in a single function but the object is defined beyond the block scope.

The rule checker flags `static` objects that are accessed in one function only but declared at file scope.

Risk

If you define an object at block scope, you or someone else is less likely to access the object inadvertently outside the block.

Example - Object Declared at File Scope but Used in One Function

```
static int ctr;   /* Non compliant */

int checkStatus(void);
void incrementCount(void);

void incrementCount(void) {
    ctr=0;
    while(1) {
        if(checkStatus())
            ctr++;
    }
}
```

In this example, the declaration of `ctr` is noncompliant because it is declared at file scope but used only in the function `incrementCount`. Declare `ctr` in the body of `incrementCount` to be MISRA C-compliant.

Check Information

Group: Rec. 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL19-C

Introduced in R2019a

CERT C: Rec. DCL22-C

Use volatile for data that cannot be cached

Description

Rule Definition

Use volatile for data that cannot be cached.

Examples

Write without a further read

Description

Write without a further read occurs when a value assigned to a variable is never read.

For instance, you write a value to a variable and then write a second value before reading the previous value. The first write operation is redundant.

Risk

Redundant write operations often indicate programming errors. For instance, you forgot to read the variable between two successive write operations or unintentionally read a different variable.

Fix

Identify the reason why you write to the variable but do not read it later. Look for common programming errors such as accidentally reading a different variable with a similar name.

If you determine that the write operation is redundant, remove the operation.

Example - Write Without Further Read Error

```
void sensor_amplification(void)
{
    extern int getsensor(void);
    int level;

    level = 4 * getsensor();
    /* Defect: Useless write */
}
```

After the variable `level` gets assigned the value `4 * getsensor()`, it is not read.

Correction — Use Value After Assignment

One possible correction is to use the variable `level` after the assignment.

```
#include <stdio.h>

void sensor_amplification(void)
{
    extern int getsensor(void);
    int level;

    level = 4 * getsensor();

    /* Fix: Use level after assignment */
    printf("The value is %d", level);

}
```

The variable `level` is printed, reading the new value.

Check Information

Group: Rec. 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL22-C

Introduced in R2019a

CERT C: Rec. DCL23-C

Guarantee that mutually visible identifiers are unique

Description

Rule Definition

Guarantee that mutually visible identifiers are unique.

Examples

External identifiers not distinct

Description

The issue occurs when external identifiers have the same first six characters for C90 or the same first 31 characters for C99.

Risk

External identifiers are ones declared with global scope or storage class `extern`.

Polyspace considers two names as distinct if there is a difference between their first 31 characters. If the difference between two names occurs only beyond the first 31 characters, they can be easily mistaken for each other. The readability of the code is reduced. For C90, the difference must occur between the first six characters. To use the C90 rules checking, use the value `c90` for the option `C standard version (-c-version)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Example - C90: First Six Characters of Identifiers Not Unique

```
int engine_temperature_raw;
int engine_temperature_scaled;   /* Non-compliant */
int engin2_temperature;          /* Compliant */
```

In this example, the identifier `engine_temperature_scaled` has the same first six characters as a previous identifier, `engine_temperature_raw`.

Example - C99: First 31 Characters of Identifiers Not Unique

```
int engine_exhaust_gas_temperature_raw;
int engine_exhaust_gas_temperature_scaled; /* Non-compliant */

int eng_exhaust_gas_temp_raw;
int eng_exhaust_gas_temp_scaled;           /* Compliant */
```

In this example, the identifier `engine_exhaust_gas_temperature_scaled` has the same first 31 characters as a previous identifier, `engine_exhaust_gas_temperature_raw`.

Example - C90: First Six Characters Identifiers in Different Translation Units Differ in Case Alone

```
/* file1.c */
int abc = 0;

/* file2.c */
int ABC = 0; /* Non-compliant */
```

In this example, the implementation supports six significant case-insensitive characters in *external identifiers*. The identifiers in the two translations are different but are not distinct in their significant characters.

Identifier in same scope and namespace not distinct

Description

The issue occurs when you declare identifiers in the same scope and namespace and the identifiers have the same first 31 characters in C90 or the same first 63 characters in C99.

Risk

Polyspace considers two names as distinct if there is a difference between their first 63 characters. If the difference between two names occurs only beyond the first 63 characters, they can be easily mistaken for each other. The readability of the code is reduced. For C90, the difference must occur between the first 31 characters. To use the C90 rules checking, use the value `c90` for the option .

Example - C90: First 31 Characters of Identifiers Not Unique

```
extern int engine_exhaust_gas_temperature_raw;
static int engine_exhaust_gas_temperature_scaled;      /* Non-compliant */

extern double engine_exhaust_gas_temperature_raw;
static double engine_exhaust_gas_temperature2_scaled;  /* Compliant */

void func ( void )
{
  /* Not in the same scope */
  int engine_exhaust_gas_temperature_local;            /* Compliant */
}
```

In this example, the identifier `engine_exhaust_gas_temperature_scaled` has the same 31 characters as a previous identifier, `engine_exhaust_gas_temperature_raw`.

The rule does not apply if the two identifiers have the same 31 characters but have different scopes. For instance, `engine_exhaust_gas_temperature_local` has the same 31 characters as `engine_exhaust_gas_temperature_raw` but different scope.

Example - C99: First 63 Characters of Identifiers Not Unique

```
extern int engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_x_raw;
static int engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_x_scale;
    /* Non-compliant */

extern int engine_gas_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx__raw;
static int engine_gas_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx__scale;
    /* Compliant */

void func ( void )
{
/* Not in the same scope */
    int engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_x_local;
          /* Compliant */
}
```

In this example, the identifier `engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_x_scale` has the same 63 characters as a previous identifier, `engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_x_raw`.

Macro identifier not distinct

Description

The issue occurs when you use macro identifiers that have the same first 31 characters in C90 or the same first 63 characters in C99.

Risk

The names of macro identifiers must be distinct from both other macro identifiers and their parameters.

Polyspace considers two names as distinct if there is a difference between their first 63 characters. If the difference between two names occurs only beyond the first 63 characters, they can be easily mistaken for each other. The readability of the code is reduced. For C90, the difference must occur between the first 31 characters. To use the C90 rules checking, use the value `c90` for the option .

Example - C90: First 31 Characters of Macro Names Not Unique

```
#define engine_exhaust_gas_temperature_raw egt_r
#define engine_exhaust_gas_temperature_scaled egt_s   /* Non-compliant */

#define engine_exhaust_gas_temp_raw egt_r
#define engine_exhaust_gas_temp_scaled egt_s          /* Compliant */
```

In this example, the macro `engine_exhaust_gas_temperature_scaled egt_s` has the same first 31 characters as a previous macro `engine_exhaust_gas_temperature_scaled`.

Example - C99: First 63 Characters of Macro Names Not Unique

```
#define engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_raw egt_r
#define engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_raw_scaled egt_s
    /* Non-compliant */

/* 63 significant case-sensitive characters in macro identifiers */
#define new_engine_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_raw egt_r
#define new_engine_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_scaled egt_s
    /* Compliant */
```

In this example, the macro `engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx___gaz_s`

`caled` has the same first 63 characters as a previous macro `engine_xxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx_xxxxxxxxx___raw`.

Name for macros and identifiers not distinct

Description

The issue occurs when identifiers are not distinct from macro names.

Risk

The rule requires that macro names that exist only prior to processing must be different from identifier names that also exist after preprocessing. Keeping macro names and identifiers distinct help avoid confusion.

Polyspace considers two names as distinct if there is a difference between their first 63 characters. If the difference between two names occurs only beyond the first 63 characters, they can be easily mistaken for each other. The readability of the code is reduced. For C90, the difference must occur between the first 31 characters. To use the C90 rules checking, use the value `c90` for the option .

Example - Macro Names Same as Identifier Names

```
#define Sum_1(x, y) ( ( x ) + ( y ) )
short Sum_1;                    /* Non-compliant */

#define Sum_2(x, y) ( ( x ) + ( y ) )
short x = Sum_2 ( 1, 2 );       /* Compliant */
```

In this example, `Sum_1` is both the name of an identifier and a macro. `Sum_2` is used only as a macro.

Example - C90: First 31 Characters of Macro Name Same as Identifier Name

```
#define       low_pressure_turbine_temperature_1 lp_tb_temp_1
static int low_pressure_turbine_temperature_2;      /* Non-compliant  */
```

In this example, the identifier `low_pressure_turbine_temperature_2` has the same first 31 characters as a previous macro `low_pressure_turbine_temperature_1`.

Check Information

Group: Rec. 02. Declarations and Initialization (DCL)

See Also

External Websites

DCL23-C

Introduced in R2019a

Rec. 03. Expressions (EXP))

CERT C: Rec. EXP00-C

Use parentheses for precedence of operation

Description

Rule Definition

Use parentheses for precedence of operation.

Examples

Possibly unintended evaluation of expression because of operator precedence rules

Description

Possibly unintended evaluation of expression because of operator precedence rules occurs when an arithmetic expression result is possibly unintended because operator precedence rules dictate an evaluation order that you do not expect.

The defect highlights expressions of the form `x` *`op_1`* `y` *`op_2`* `z`. Here, *`op_1`* and *`op_2`* are operator combinations that commonly induce this error. For instance, `x == y | z`.

The checker does not flag all operator combinations. For instance, `x == y || z` is not flagged because you most likely intended to perform a logical OR between `x == y` and `z`. Specifically, the checker flags these combinations:

- && and ||: For instance, `x || y && z` or `x && y || z`.
- Assignment and bitwise operations: For instance, `x = y | z`.
- Assignment and comparison operations: For instance, `x = y != z` or `x = y > z`.
- Comparison operations: For instance, `x > y > z` (except when one of the comparisons is an equality `x == y > z`).

- Shift and numerical operation: For instance, `x << y + 2`.
- Pointer dereference and arithmetic: For instance, `*p++`.

Risk

The defect can cause the following issues:

- If you or another code reviewer reviews the code, the intended order of evaluation is not immediately clear.
- It is possible that the result of the evaluation does not meet your expectations. For instance:
  - In the operation `*p++`, it is possible that you expect the dereferenced value to be incremented. However, the pointer `p` is incremented before the dereference.
  - In the operation `(x == y | z)`, it is possible that you expect `x` to be compared with `y | z`. However, the == operation happens before the | operation.

Fix

See if the order of evaluation is what you intend. If not, apply parentheses to implement the evaluation order that you want.

For better readability of your code, it is good practice to apply parenthesis to implement an evaluation order even when operator precedence rules impose that order.

Example - Expressions with Possibly Unintended Evaluation Order

```
int test(int a, int b, int c) {
    return(a & b == c);
}
```

In this example, the == operation happens first, followed by the & operation. If you intended the reverse order of operations, the result is not what you expect.

Correction — Parenthesis For Intended Order

One possible correction is to apply parenthesis to implement the intended evaluation order.

```
int test(int a, int b, int c) {
    return((a & b) == c);
}
```

Check Information

Group: Rec. 03. Expressions (EXP)

See Also

External Websites

EXP00-C

Introduced in R2019a

CERT C: Rec. EXP05-C

Do not cast away a const qualification

Description

Rule Definition

Do not cast away a const qualification.

Examples

Cast to pointer that removes `const` or `volatile` qualification

Description

Polyspace flags both implicit and explicit conversions that violate this rule.

Risk

This rule forbids:

- Casts from a pointer to a `const` object to a pointer that does not point to a `const` object.
- Casts from a pointer to a `volatile` object to a pointer that does not point to a `volatile` object.

Such casts violate type qualification. For example, the `const` qualifier indicates the read-only status of an object. If a cast removes the qualifier, the object is no longer read-only.

Example - Casts That Remove Qualifiers

```
void foo(void) {

    /* Cast on simple type */
    unsigned short           x;
```

```
    unsigned short * const   cpi = &x;  /* const pointer */
    unsigned short * const  *pcpi;   /* pointer to const pointer */
    unsigned short **ppi;
    const unsigned short    *pci;    /* pointer to const */
    volatile unsigned short *pvi;    /* pointer to volatile  */
    unsigned short          *pi;

    pi = cpi;                        /* Compliant - no cast required */
    pi  = (unsigned short *)  pci;   /* Non-compliant */
    pi  = (unsigned short *)  pvi;   /* Non-compliant */
    ppi = (unsigned short **)pcpi;   /* Non-compliant */
}
```

In this example:

- The variables `pci` and `pcpi` have the `const` qualifier in their type. The rule is violated when the variables are cast to types that do not have the `const` qualifier.
- The variable `pvi` has a `volatile` qualifier in its type. The rule is violated when the variable is cast to a type that does not have the `volatile` qualifier.

Even though `cpi` has a `const` qualifier in its type, the rule is not violated in the statement `p=cpi;`. The assignment does not cause a type conversion because both `p` and `cpi` have type `unsigned short`.

Check Information

Group: Rec. 03. Expressions (EXP)

See Also

External Websites

EXP05-C

Introduced in R2019a

CERT C: Rec. EXP08-C

Ensure pointer arithmetic is used correctly

Description

Rule Definition

Ensure pointer arithmetic is used correctly.

Examples

Pointer points outside array after arithmetic on pointer operand

Description

This issue occurs when a pointer resulting from arithmetic on a pointer operand points to an element outside the array of that pointer operand.

Risk

Using an invalid array subscript can lead to erroneous behavior of the program. Run-time derived array subscripts are especially troublesome because they cannot be easily checked by manual review or static analysis.

The C Standard defines the creation of a pointer to one beyond the end of the array. The rule permits the C Standard. Dereferencing a pointer to one beyond the end of an array causes undefined behavior and is noncompliant.

Subtraction between pointers to different arrays

Description

This rule is raised whenever the analysis detects a `Subtraction or comparison between pointers to different arrays`.

Risk

This rule applies to expressions of the form `pointer_expression1 - pointer_expression2`. The behavior is undefined if `pointer_expression1` and `pointer_expression2`:

- Do not point to elements of the same array,
- Or do not point to the element one beyond the end of the array.

Example - Subtracting Pointers

```
#include <stddef.h>

void f1 (int32_t *ptr)
{
    int32_t a1[10];
    int32_t a2[10];
    int32_t *p1 = &a1[ 1];
    int32_t *p2 = &a2[10];
    ptrdiff_t diff1, diff2, diff3;

    diff1 =  p1 - a1;   // Compliant
    diff2 =  p2 - a2;   // Compliant
    diff3 =  p1 - p2;   // Non-compliant
}
```

In this example, the three subtraction expressions show the difference between compliant and noncompliant pointer subtractions. The `diff1` and `diff2` subtractions are compliant because the pointers point to the same array. The `diff3` subtraction is not compliant because `p1` and `p2` point to different arrays.

Incorrect pointer scaling

Description

Incorrect pointer scaling occurs when Polyspace Bug Finder considers that you are ignoring the implicit scaling in pointer arithmetic.

For instance, the defect can occur in the following situations.

Situation	Risk	Possible Fix
You use the `sizeof` operator in arithmetic operations on a pointer.	The `sizeof` operator returns the size of a data type in number of bytes. Pointer arithmetic is already implicitly scaled by the size of the data type of the pointed variable. Therefore, the use of `sizeof` in pointer arithmetic produces unintended results.	Do not use `sizeof` operator in pointer arithmetic.
You perform arithmetic operations on a pointer, and then apply a cast.	Pointer arithmetic is implicitly scaled. If you do not consider this implicit scaling, casting the result of a pointer arithmetic produces unintended results.	Apply the cast before the pointer arithmetic.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Use of `sizeof` Operator

```
void func(void) {
    int arr[5] = {1,2,3,4,5};
    int *ptr = arr;

    int value_in_position_2 = *(ptr + 2*(sizeof(int)));
}
```

In this example, the operation `2*(sizeof(int))` returns twice the size of an `int` variable in bytes. However, because pointer arithmetic is implicitly scaled, the number of bytes by which `ptr` is offset is `2*(sizeof(int))*(sizeof(int))`.

In this example, the incorrect scaling shifts `ptr` outside the bounds of the array. Therefore, a **Pointer access out of bounds** error appears on the * operation.

Correction — Remove `sizeof` Operator

One possible correction is to remove the `sizeof` operator.

```
void func(void) {
    int arr[5] = {1,2,3,4,5};
    int *ptr = arr;

    int value_in_position_2 = *(ptr + 2);
}
```

Example - Cast Following Pointer Arithmetic

```
int func(void) {
    int x = 0;
    char r = *(char *)(&x + 1);
    return r;
}
```

In this example, the operation `&x + 1` offsets `&x` by `sizeof(int)`. Following the operation, the resulting pointer points outside the allowed buffer. When you dereference the pointer, a **Pointer access out of bounds** error appears on the * operation.

Correction — Apply Cast Before Pointer Arithmetic

If you want to access the second byte of `x`, first cast `&x` to a `char*` pointer and then perform the pointer arithmetic. The resulting pointer is offset by `sizeof(char)` bytes and still points within the allowed buffer, whose size is `sizeof(int)` bytes.

```
int func(void) {
    int x = 0;
    char r = *((char *)(&x )+ 1);
    return r;
}
```

Check Information

Group: Rec. 03. Expressions (EXP)

See Also

External Websites

EXP08-C

Introduced in R2019a

CERT C: Rec. EXP09-C

Use sizeof to determine the size of a type or variable

Description

Rule Definition

Use sizeof to determine the size of a type or variable.

Examples

Hard-coded object size used to manipulate memory

Description

Hard-coded object size used to manipulate memory occurs on constants that are memory size arguments for memory functions such as `malloc` or `memset`.

Risk

If you hard code object size, your code is not portable to architectures with different type sizes. If the constant value is not the same as the object size, the buffer might or might not overflow.

Fix

For the size argument of memory functions, use `sizeof(`*`object`*`)`.

Example - Assume 4-Byte Integer Pointers

```
#include <stddef.h>
#include <stdlib.h>
enum {
    SIZE3   = 3,
    SIZE20  = 20
};
```

```
extern void fill_ints(int **matrix, size_t nb, size_t s);

void bug_hardcodedmemsize()
{
    size_t i, s;

    s = 4;
    int **matrix = (int **)calloc(SIZE20, s);
    if (matrix == NULL) {
        return; /* Indicate calloc() failure */
    }
    fill_ints(matrix, SIZE20, s);
    free(matrix);
}
```

In this example, the memory allocation function `calloc` is called with a memory size of 4. The memory is allocated for an integer pointer, which can be a more or less than 4 bytes depending on your target. If the integer pointer is not 4 bytes, your program can fail.

Correction — Use `sizeof(int *)`

When calling `calloc`, replace the hard-coded size with a call to `sizeof`. This change makes your code more portable.

```
#include <stddef.h>
#include <stdlib.h>
enum {
    SIZE3   = 3,
    SIZE20  = 20
};
extern void fill_ints(int **matrix, size_t nb, size_t s);

void corrected_hardcodedmemsize()
{
    size_t i, s;

    s = sizeof(int *);
    int **matrix = (int **)calloc(SIZE20, s);
    if (matrix == NULL) {
        return; /* Indicate calloc() failure */
    }
    fill_ints(matrix, SIZE20, s);
    free(matrix);
}
```

Check Information

Group: Rec. 03. Expressions (EXP)

See Also

External Websites

EXP09-C

Introduced in R2019a

CERT C: Rec. EXP10-C

Do not depend on the order of evaluation of subexpressions or the order in which side effects take place

Description

Rule Definition

Do not depend on the order of evaluation of subexpressions or the order in which side effects take place.

Examples

Expression value depends on order of evaluation or of side effects

Description

The issue occurs when the value of an expression and its persistent side effects is not the same under all permitted evaluation orders.

An expression can have different values under the following conditions:

- The same variable is modified more than once in the expression, or is both read and written.
- The expression allows more than one order of evaluation.

Therefore, this rule forbids expressions where a variable is modified more than once and can cause different results under different orders of evaluation.

Risk

If an expression results in different values depending on the order of evaluation, its value becomes implementation-defined.

Example - Variable Modified More Than Once in Expression

```
int a[10], b[10];
#define COPY_ELEMENT(index) (a[(index)]=b[(index)])

void main () {
    int i=0, k=0;

    COPY_ELEMENT (k);         /* Compliant */
    COPY_ELEMENT (i++);       /* Noncompliant  */
}
```

In this example, the rule is violated by the statement `COPY_ELEMENT(i++)` because `i++` occurs twice and the order of evaluation of the two expressions is unspecified.

Example - Variable Modified and Used in Multiple Function Arguments

```
void f (unsigned int param1, unsigned int param2) {}

void main () {
    unsigned int i=0;
    f ( i++, i );                 /* Non-compliant */
}
```

In this example, the rule is violated because it is unspecified whether the operation `i++` occurs before or after the second argument is passed to `f`. The call `f(i++,i)` can translate to either `f(0,0)` or `f(0,1)`.

Check Information

Group: Rec. 03. Expressions (EXP)

See Also

External Websites

EXP10-C

Introduced in R2019a

CERT C: Rec. EXP11-C

Do not make assumptions regarding the layout of structures with bit-fields

Description

Rule Definition

Do not make assumptions regarding the layout of structures with bit-fields.

Examples

Justification of implementation-defined behavior

Description

The issue occurs when you do not justify implementation-defined behavior that the analysis detects in your code.

The analysis detects the following possibilities of implementation-defined behavior in C99 and their counterparts in C90. If you know the behavior of your compiler implementation, justify the analysis result with appropriate comments. To justify a result, assign one of these statuses: `Justified`, `No action planned`, or `Not a defect`.

Tip To mass-justify all results that indicate the same implementation-defined behavior, use the **Detail** column on the **Results List** pane. Click the column header so that all results with the same entry are grouped together. Select the first result and then select the last result while holding the `Shift` key. Assign a status to one of the results. If you do not see the **Detail** column, right-click any other column header and enable this column.

C99 Standard Annex Ref	Behavior to Be Documented	How Polyspace Helps

J.3.2: Environment	An alternative manner in which `main` function may be defined.	The analysis flags `main` with arguments and return types other than:
		`int main(void) { ... }`
		or
		`int main(int argc, char *argv[]) { ... }`
		See section 5.1.2.2.1 of the C99 Standard.

J.3.2: Environment	The set of environment names and the method for altering the environment list used by the `getenv` function.	The analysis flags uses of the `getenv` function. For this function, you need to know the list of environment variables and how the list is modified. See section 7.20.4.5 of the C99 Standard.
J.3.6: Floating Point	The rounding behaviors characterized by non-standard values of `FLT_ROUNDS`.	The analysis flags the include of `float.h` if values of `FLT_ROUNDS` are outside the set, {-1, 0, 1, 2, 3}. Only the values in this set lead to well-defined rounding behavior. See section 5.2.4.2.2 of the C99 Standard.
J.3.6: Floating Point	The evaluation methods characterized by non-standard negative values of `FLT_EVAL_METHOD`.	The analysis flags the include of `float.h` if values of `FLT_EVAL_METHOD` are outside the set, {-1, 0, 1, 2}. Only the values in this set lead to well-defined behavior for floating-point operations. See section 5.2.4.2.2 of the C99 Standard.

C99 Standard Annex Ref	Behavior to Be Documented	How Polyspace Helps
J.3.6: Floating Point	The direction of rounding when an integer is converted to a floating-point number that cannot exactly represent the original value.	The analysis flags conversions from integer to floating-point data types of smaller size (for example, 64-bit `int` to 32-bit `float`). See section 6.3.1.4 of the C99 Standard.
J.3.6: Floating Point	The direction of rounding when a floating-point number is converted to a narrower floating-point number.	The analysis flags these conversions: • `double` to `float` • `long double` to `double` or `float` See section 6.3.1.5 of the C99 Standard.

J.3.6: Floating Point	The default state for the `FENV_ACCESS` pragma.	The analysis flags use of the pragma other than:
		`#pragma STDC FENV_ACCESS ON`
		or
		`#pragma STDC FENV_ACCESS OFF`
		See section 7.6.1 of the C99 Standard.

J.3.6: Floating Point	The default state for the `FP_CONTRACT` pragma.	The analysis flags use of the pragma other than:
		`#pragma STDC FP_CONTRACT ON`
		or
		`#pragma STDC FP_CONTRACT OFF`
		See section 7.12.2 of the C99 Standard.

C99 Standard Annex Ref	Behavior to Be Documented	How Polyspace Helps
J.3.11: Preprocessing Directives	The behavior on each recognized non-STDC #pragma directive.	The analysis flags the pragma usage: `#pragma` *`pp-tokens`* where the processing token `STDC` does not immediately follow`pragma`. For instance: `#pragma FENV_ACCESS ON` See section 6.10.6 of the C99 Standard.
J.3.12: Library Functions	Whether the `feraiseexcept` function raises the ‘‘inexact’’ floating-point exception in addition to the ‘‘overflow’’ or ‘‘underflow’’ floating-point exception.	The analysis flags calls to the `feraiseexcept` function. See section 7.6.2.3 of the C99 Standard.
J.3.12: Library Functions	Strings other than `"C"` and `""` that may be passed as the second argument to the `setlocale` function.	The analysis flags calls to the `setlocale` function when its second argument is not `"C"` or `""`. See section 7.11.1.1 of the C99 Standard.
J.3.12: Library Functions	The types defined for `float_t` and `double_t` when the value of the `FLT_EVAL_METHOD` macro is less than 0 or greater than 2.	The analysis flags the include of `math.h` if `FLT_EVAL_METHOD` has values outside the set {0,1,2}. See section 7.12 of the C99 Standard.

C99 Standard Annex Ref	Behavior to Be Documented	How Polyspace Helps
J.3.12: Library Functions	The base-2 logarithm of the modulus used by the `remquo` functions in reducing the quotient.	The analysis flags calls to the `remquo`, `remquof` and `remquol` function. See section 7.12.10.3 of the C99 Standard.
J.3.12: Library Functions	The termination status returned to the host environment by the `abort`, `exit`, or `_Exit` function.	The analysis flags calls to the `abort`, `exit`, or `_Exit` function. See sections 7.20.4.1, 7.20.4.3 or 7.20.4.4 of the C99 Standard.

Risk

A code construct has implementation-defined behavior if the C standard allows compilers to choose their own specifications for the construct. The full list of implementation-defined behavior is available in Annex J.3 of the standard ISO/IEC 9899:1999 (C99) and in Annex G.3 of the standard ISO/IEC 9899:1990 (C90).

If you understand and document all implementation-defined behavior, you can be assured that all output of your program is intentional and not produced by chance.

Check Information

Group: Rec. 03. Expressions (EXP)

See Also

External Websites

EXP11-C

Introduced in R2019a

CERT C: Rec. EXP12-C

Do not ignore values returned by functions

Description

Rule Definition

Do not ignore values returned by functions.

Examples

Returned value of a sensitive function not checked

Description

Returned value of a sensitive function not checked occurs when you call sensitive standard functions, but you:

- Ignore the return value.
- Use an output or a return value without testing the validity of the return value.

For this defect, two type of functions are considered: ***sensitive*** and ***critical sensitive***.

A ***sensitive*** function is a standard function that can encounter:

- Exhausted system resources (for example, when allocating resources)
- Changed privileges or permissions
- Tainted sources when reading, writing, or converting data from external sources
- Unsupported features despite an existing API

A ***critical sensitive*** function is a sensitive function that performs one of these critical or vulnerable tasks:

- Set privileges (for example, `setuid`)
- Create a jail (for example, `chroot`)
- Create a process (for example, `fork`)
- Create a thread (for example, `pthread_create`)
- Lock or unlock mutex (for example, `pthread_mutex_lock`)
- Lock or unlock memory segments (for example, `mlock`)

Risk

If you do not check the return value of functions that perform sensitive or critical sensitive tasks, your program can behave unexpectedly. Errors from these functions can propagate throughout the program causing incorrect output, security vulnerabilities, and possibly system failures.

Fix

Before continuing with the program, test the return value of *critical sensitive* functions.

For *sensitive functions*, you can explicitly ignore a return value by casting the function to `void`. Polyspace does not raise this defect for sensitive functions cast to void. This resolution is not accepted for *critical sensitive functions* because they perform more vulnerable tasks.

Example - Sensitive Function Return Ignored

```
#include <pthread.h>

void initialize() {
    pthread_attr_t attr;

    pthread_attr_init(&attr);
}
```

This example shows a call to the sensitive function `pthread_attr_init`. The return value of `pthread_attr_init` is ignored, causing a defect.

Correction — Cast Function to `(void)`

One possible correction is to cast the function to void. This fix informs Polyspace and any reviewers that you are explicitly ignoring the return value of the sensitive function.

```
#include <pthread.h>

void initialize() {
    pthread_attr_t attr;

    (void)pthread_attr_init(&attr);
}
```

Correction — Test Return Value

One possible correction is to test the return value of `pthread_attr_init` to check for errors.

```
#include <pthread.h>
#include <stdlib.h>
#define fatal_error() abort()

void initialize() {
    pthread_attr_t attr;
    int result;

    result = pthread_attr_init(&attr);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }
}
```

Example - Critical Function Return Ignored

```
#include <pthread.h>
extern void *start_routine(void *);

void returnnotchecked() {
    pthread_t thread_id;
    pthread_attr_t attr;
    void *res;

    (void)pthread_attr_init(&attr);
    (void)pthread_create(&thread_id, &attr, &start_routine, ((void *)0));
    pthread_join(thread_id,  &res);
}
```

In this example, two critical functions are called: `pthread_create` and `pthread_join`. The return value of the `pthread_create` is ignored by casting to void, but because

`pthread_create` is a critical function (not just a sensitive function), Polyspace does not ignore this *Return value of a sensitive function not checked* defect. The other critical function, `pthread_join`, returns value that is ignored implicitly. `pthread_join` uses the return value of `pthread_create`, which was not checked.

Correction — Test the Return Value of Critical Functions

The correction for this defect is to check the return value of these critical functions to verify the function performed as expected.

```
#include <pthread.h>
#include <stdlib.h>
#define fatal_error() abort()

extern void *start_routine(void *);

void returnnotchecked() {
    pthread_t thread_id;
    pthread_attr_t attr;
    void *res;
    int result;

    (void)pthread_attr_init(&attr);
    result = pthread_create(&thread_id, &attr, &start_routine, NULL);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }

    result = pthread_join(thread_id,  &res);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }
}
```

Check Information

Group: Rec. 03. Expressions (EXP)

See Also

External Websites

EXP12-C

Introduced in R2019a

CERT C: Rec. EXP13-C

Treat relational and equality operators as if they were nonassociative

Description

Rule Definition

Treat relational and equality operators as if they were nonassociative.

Examples

Possibly unintended evaluation of expression because of operator precedence rules

Description

Possibly unintended evaluation of expression because of operator precedence rules occurs when an arithmetic expression result is possibly unintended because operator precedence rules dictate an evaluation order that you do not expect.

The defect highlights expressions of the form `x` *`op_1`* `y` *`op_2`* `z`. Here, *`op_1`* and *`op_2`* are operator combinations that commonly induce this error. For instance, `x == y | z`.

The checker does not flag all operator combinations. For instance, `x == y || z` is not flagged because you most likely intended to perform a logical OR between `x == y` and `z`. Specifically, the checker flags these combinations:

- && and ||: For instance, `x || y && z` or `x && y || z`.
- Assignment and bitwise operations: For instance, `x = y | z`.
- Assignment and comparison operations: For instance, `x = y != z` or `x = y > z`.
- Comparison operations: For instance, `x > y > z` (except when one of the comparisons is an equality `x == y > z`).

- Shift and numerical operation: For instance, `x << y + 2`.
- Pointer dereference and arithmetic: For instance, `*p++`.

Risk

The defect can cause the following issues:

- If you or another code reviewer reviews the code, the intended order of evaluation is not immediately clear.
- It is possible that the result of the evaluation does not meet your expectations. For instance:
  - In the operation `*p++`, it is possible that you expect the dereferenced value to be incremented. However, the pointer `p` is incremented before the dereference.
  - In the operation `(x == y | z)`, it is possible that you expect `x` to be compared with `y | z`. However, the == operation happens before the | operation.

Fix

See if the order of evaluation is what you intend. If not, apply parentheses to implement the evaluation order that you want.

For better readability of your code, it is good practice to apply parenthesis to implement an evaluation order even when operator precedence rules impose that order.

Example - Expressions with Possibly Unintended Evaluation Order

```
int test(int a, int b, int c) {
    return(a & b == c);
}
```

In this example, the == operation happens first, followed by the & operation. If you intended the reverse order of operations, the result is not what you expect.

Correction — Parenthesis For Intended Order

One possible correction is to apply parenthesis to implement the intended evaluation order.

```
int test(int a, int b, int c) {
    return((a & b) == c);
}
```

Check Information

Group: Rec. 03. Expressions (EXP)

See Also

External Websites

EXP13-C

Introduced in R2019a

CERT C: Rec. EXP19-C

Use braces for the body of an if, for, or while statement

Description

Rule Definition

Use braces for the body of an if, for, or while statement.

Examples

Iteration or selection statement body not enclosed in braces

Description

The issue occurs when you do not enclose the body of an iteration-statement or a selection-statement in braces.

Risk

The rule applies to:

- Iteration statements such as `while`, `do ... while` or `for`.
- Selection statements such as `if ... else` or `switch`.

If the block of code associated with an iteration or selection statement is not contained in braces, you can make mistakes about the association. For example:

- You can wrongly associate a line of code with an iteration or selection statement because of its indentation.
- You can accidentally place a semicolon following the iteration or selection statement. Because of the semicolon, the line following the statement is no longer associated with the statement even though you intended otherwise.

Example - Iteration Block

```
int data_available = 1;
void f1(void) {
    while(data_available)                /* Non-compliant */
        process_data();

    while(data_available) {              /* Compliant */
        process_data();
    }
}
```

In this example, the second `while` block is enclosed in braces and does not violate the rule.

Example - Nested Selection Statements

```
void f1(void) {
    if(flag_1)                           /* Non-compliant */
        if(flag_2)                       /* Non-compliant */
            action_1();
    else                                 /* Non-compliant */
            action_2();
}
```

In this example, the rule is violated because the `if` or `else` blocks are not enclosed in braces. Unless indented as above, it is easy to associate the `else` statement with the inner `if`.

Correction — Place Selection Statement Block in Braces

One possible correction is to enclose each block associated with an `if` or `else` statement in braces.

```
void f1(void) {
    if(flag_1) {                         /* Compliant */
        if(flag_2) {                       /* Compliant */
            action_1();
        }
    }
    else {                               /* Compliant */
        action_2();
    }
}
```

Example - Spurious Semicolon After Iteration Statement

```
void f1(void) {
    while(flag_1);                          /* Non-compliant */
    {
        flag_1 = action_1();
    }
}
```

In this example, the rule is violated even though the `while` statement is followed by a block in braces. The semicolon following the `while` statement causes the block to dissociated from the `while` statement.

The rule helps detect such spurious semicolons.

Check Information

Group: Rec. 03. Expressions (EXP)

See Also

External Websites

EXP19-C

Introduced in R2019a

Rec. 04. Integers (INT)

CERT C: Rec. INT00-C

Understand the data model used by your implementation(s)

Description

Rule Definition

Understand the data model used by your implementation(s).

Examples

Use of basic types declarations and definitions of variables or functions

Description

The issue occurs when you use basic numerical types instead of `typedefs` that indicate size and signedness.

The rule checker flags use of basic data types in variable or function declarations and definitions. The rule enforces use of `typedef`s instead.

The rule checker does not flag the use of basic types in the `typedef` statements themselves.

Risk

When the amount of memory being allocated is important, using specific-length types makes it clear how much storage is being reserved for each object.

Example - Direct Use of Basic Types in Definitions

```
typedef unsigned int uint32_t;

int x = 0;       /* Non compliant */
uint32_t y = 0;  /* Compliant */
```

In this example, the declaration of `x` is noncompliant because it uses a basic type directly.

Integer overflow

Description

Integer overflow occurs when an operation on integer variables can result in values that cannot be represented by the result data type. The data type of a variable determines the number of bytes allocated for the variable storage and constrains the range of allowed values.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Integer overflows on signed integers result in undefined behavior.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variables in the overflowing computation acquire their current values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

You can fix the defect by:

- Using a bigger data type for the result of the operation so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

To avoid overflows in general, try one of these techniques:

- Keep integer variable values restricted to within half the range of signed integers.
- In operations that might overflow, check for conditions that can lead to the overflow and implement wrap around or saturation behavior depending on how the result of the operation is used. The result then becomes predictable and can be safely used in subsequent computations.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Addition of Maximum Integer

```
#include <limits.h>

int plusplus(void) {

    int var = INT_MAX;
    var++;
    return var;
}
```

In the third statement of this function, the variable `var` is increased by one. But the value of `var` is the maximum integer value, so an `int` cannot represent one plus the maximum integer value.

Correction — Different Storage Type

One possible correction is to change data types. Store the result of the operation in a larger data type (Note that on a 32-bit machine, `int` and `long` has the same size). In this example, on a 32-bit machine, by returning a `long long` instead of an `int`, the overflow error is fixed.

```
#include <limits.h>

long long plusplus(void) {

    long long lvar = INT_MAX;
    lvar++;
    return lvar;
}
```

Integer constant overflow

Description

Integer constant overflow occurs when you assign a compile-time constant to a signed integer variable whose data type cannot accommodate the value. An `n`-bit signed integer holds values in the range $[-2^{n-1}, 2^{n-1}-1]$.

For instance, `c` is an 8-bit signed `char` variable that cannot hold the value 255.

```
signed char c = 255;
```

To determine the sizes of fundamental types, Bug Finder uses your specification for `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

The default behavior for constant overflows can vary between compilers and platforms. Retaining constant overflows can reduce the portability of your code.

Even if your compilers wraps around overflowing constants with a warning, the wrap-around behavior can be unintended and cause unexpected results.

Fix

Check if the constant value is what you intended. If the value is correct, use a different, possibly wider, data type for the variable.

Example - Overflowing Constant from Macro Expansion

```
#define MAX_UNSIGNED_CHAR 255
#define MAX_SIGNED_CHAR 127

void main() {
    char c1 = MAX_UNSIGNED_CHAR;
    char c2 = MAX_SIGNED_CHAR+1;
}
```

In this example, the defect appears on the macros because at least one use of the macro causes an overflow. To reproduce these defects, use a `Target processor type (-target)` where `char` is signed by default. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Correction — Use Different Data Type

One possible correction is to use a different data type for the variables that overflow.

```
#define MAX_UNSIGNED_CHAR 255
#define MAX_SIGNED_CHAR 127

void main() {
```

```
    unsigned char c1 = MAX_UNSIGNED_CHAR;
    unsigned char c2 = MAX_SIGNED_CHAR+1;
}
```

Format string specifiers and arguments mismatch

Description

Format string specifiers and arguments mismatch occurs when the format specifiers in the formatted output functions such as `printf` do not match their corresponding arguments. For example, an argument of type `unsigned long` must have a format specification of `%lu`.

Risk

Mismatch between format specifiers and the corresponding arguments result in undefined behavior.

Fix

Make sure that the format specifiers match the corresponding arguments. For instance, in this example, the `%d` specifier does not match the string argument `message` and the `%s` specifier does not match the integer argument `err_number`.

```
  const char *message = "License not available";
  int err_number = ;-4
  printf("Error: %d (error type %s)\n", message, err_number);
```

Switching the two format specifiers fixes the issue. See the specifications for the printf function for more information about format specifiers.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Printing a Float

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;
```

```
    printf("%d\n", fst);
}
```

In the `printf` statement, the format specifier, `%d`, does not match the data type of `fst`.

Correction — Use an Unsigned Long Format Specifier

One possible correction is to use the `%lu` format specifier. This specifier matches the `unsigned` integer type and `long` size of `fst`.

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;

    printf("%lu\n", fst);
}
```

Correction — Use an Integer Argument

One possible correction is to change the argument to match the format specifier. Convert `fst` to an integer to match the format specifier and print the value `1`.

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;

    printf("%d\n", (int)fst);
}
```

Check Information

Group: Rec. 04. Integers (INT)

See Also

External Websites

INT00-C

Introduced in R2019a

CERT C: Rec. INT02-C

Understand integer conversion rules

Description

Rule Definition

Understand integer conversion rules.

Examples

Sign change integer conversion overflow

Description

Sign change integer conversion overflow occurs when converting an unsigned integer to a signed integer. If the variable does not have enough bytes to represent both the original constant and the sign bit, the conversion overflows.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Convert from `unsigned char` to `char`

```
char sign_change(void) {
    unsigned char count = 255;

    return (char)count;
}
```

In the return statement, the unsigned character variable `count` is converted to a signed character. However, `char` has 8 bits, 1 for the sign of the constant and 7 to represent the number. The conversion operation overflows because 255 uses 8 bits.

Correction — Change conversion types

One possible correction is using a larger integer type. By using an `int`, there are enough bits to represent the sign and the number value.

```
int sign_change(void) {
    unsigned char count = 255;

    return (int)count;
}
```

Check Information

Group: Rec. 04. Integers (INT)

See Also

External Websites

INT02-C

Introduced in R2019a

CERT C: Rec. INT04-C

Enforce limits on integer values originating from tainted sources

Description

Rule Definition

Enforce limits on integer values originating from tainted sources.

Examples

Array access with tainted index

Description

Array access with tainted index detects reading or writing to an array by using a tainted index that has not been validated.

Risk

The index might be outside the valid array range. If the tainted index is outside the array range, it can cause:

- Buffer underflow/underwrite — writing to memory before the beginning of the buffer.
- Buffer overflow — writing to memory after the end of a buffer.
- Over-reading a buffer — accessing memory after the end of the targeted buffer.
- Under-reading a buffer, or accessing memory before the beginning of the targeted buffer.

An attacker can use an invalid read or write operation create to problems in your program.

Fix

Before using the index to access the array, validate the index value to make sure that it is inside the array range.

Example - Use Index to Return Buffer Value

```
#define SIZE100 100
extern int tab[SIZE100];

int taintedarrayindex(int num) {
    return tab[num];
}
```

In this example, the index `num` accesses the array `tab`. The function does not check to see if `num` is inside the range of `tab`.

Correction — Check Range Before Use

One possible correction is to check that `num` is in range before using it.

```
#define SIZE100 100
extern int tab[SIZE100];

int taintedarrayindex(int num) {
    if (num >= 0 && num < SIZE100) {
            return tab[num];
    } else {
        return -9999;
    }
}
```

Loop bounded with tainted value

Description

Loop bounded with tainted value detects loops that are bounded by values from an unsecure source.

Risk

A tainted value can cause over looping or infinite loops. Attackers can use this vulnerability to crash your program or cause other unintended behavior.

Fix

Before starting the loop, validate unknown boundary and iterator values.

Example - Loop Boundary From Input Argument

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int taintedloopboundary(int count) {
    int res = 0;
    for (int i=0 ; i < count; ++i) {
        res += i;
    }
    return res;
}
```

In this example, the function uses the input argument to loop `count` times. `count` could be any number because the value is not checked before starting the for-loop.

Correction — Check Loop Control

One possible correction is to check the value of the variable controlling the loop before starting the for-loop. This example checks if `count` is greater than zero and less than the maximum size.

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int taintedloopboundary(int count) {
    int res = 0;

    if (count>0 && count<SIZE128) {
        for (int i=0 ; i<count ; ++i) {
            res += i;
        }
    }
    return res;
}
```

Memory allocation with tainted size

Description

Memory allocation with tainted size checks memory allocation functions, such as `calloc` or `malloc`, for size arguments from unsecured sources.

Risk

Uncontrolled memory allocation can cause your program to request too much system memory. This consequence can lead to a crash due to an out-of-memory condition, or assigning too many resources.

Fix

Before allocating memory, check the value of your arguments to check that they do not exceed the bounds.

Example - Allocate Memory Using Input Argument

```
#include "stdlib.h"

int* bug_taintedmemoryallocsize(size_t size) {
    int* p = (int*)malloc(size);
    return p;
}
```

In this example, `malloc` allocates `size` amount of memory for the pointer `p`. `size` is an outside variable, so could be any size value. If the size is larger than the amount of memory you have available, your program could crash.

Correction — Check Size of Memory to be Allocated

One possible correction is to check the size of the memory that you want to allocate before performing the `malloc` operation. This example checks to see if the size is positive and less than the maximum size.

```
#include "stdlib.h"

enum {
    SIZE10  =  10,
```

```
    SIZE100 = 100,
    SIZE128 = 128
};

int* corrected_taintedmemoryallocsize(int size) {
    int* p = NULL;
    if (size>0 && size<SIZE128) {          /* Fix: Check entry range before use */
        p = (int*)malloc((unsigned int)size);
    }
    return p;
}
```

Tainted size of variable length array

Description

Tainted size of variable length array detects variable length arrays (VLA) whose size is from an unsecure source.

Risk

If an attacker changed the size of your VLA to an unexpected value, it can cause your program to crash or behave unexpectedly.

If the size is non-positive, the behavior of the VLA is undefined. Your program does not perform as expected.

If the size is unbounded, the VLA can cause memory exhaustion or stack overflow.

Fix

Validate your VLA size to make sure that it is positive and less than a maximum value.

Example - Input Argument Used as Size of VLA

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int taintedvlasize(int size) {
```

```
    int tabvla[size];
    int res = 0;
    for (int i=0 ; i<SIZE10 ; ++i) {
        tabvla[i] = i*i;
        res += tabvla[i];
    }
    return res;
}
```

In this example, a variable length array size is based on an input argument. Because this input argument value is not checked, the size may be negative or too large.

Correction — Check VLA Size

One possible correction is to check the size variable before creating the variable length array. This example checks if the size is larger than 10 and less than 100, before creating the VLA

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int taintedvlasize(int size) {
    int res = 0;
    if (size>SIZE10 && size<SIZE100) {
        int tabvla[size];
        for (int i=0 ; i<SIZE10 ; ++i) {
            tabvla[i] = i*i;
            res += tabvla[i];
        }
    }
    return res;
}
```

Check Information

Group: Rec. 04. Integers (INT)

See Also

External Websites

INT04-C

Introduced in R2019a

CERT C: Rec. INT07-C

Use only explicitly signed or unsigned char type for numeric values

Description

Rule Definition

Use only explicitly signed or unsigned char type for numeric values.

Examples

Use of plain char type for numerical value

Description

Use of plain char type for numerical value detects `char` variables without explicit signedness that are being used in these ways:

- To store non-char constants
- In an arithmetic operation when the `char` is:
  - A negative value.
  - The result of a sign changing overflow.
- As a buffer offset.

`char` variables without a `signed` or `unsigned` qualifier can be either signed or unsigned depending on your compiler.

Risk

Operations on a plain char can result in unexpected numerical values. If the char is used as an offset, the char can cause buffer overflow or underflow.

Fix

When initializing a char variable, to avoid implementation-defined confusion, explicitly state whether the char is signed or unsigned.

Example - Divide by `char` Variable

```
#include <stdio.h>

void badplaincharuse(void)
{
    char c = 200;
    int i = 1000;
    (void)printf("i/c = %d\n", i/c);
}
```

In this example, the char variable `c` can be signed or unsigned depending on your compiler. Assuming 8-bit, two's complement character types, the result is either `i/c = 5` (unsigned char) or `i/c = -17` (signed char). The correct result is unknown without knowing the signedness of `char`.

Correction — Add `signed` Qualifier

One possible correction is to add a `signed` qualifier to `char`. This clarification makes the operation defined.

```
#include <stdio.h>

void badplaincharuse(void)
{
    signed char c = -56;
    int i = 1000;
    (void)printf("i/c = %d\n", i/c);
}
```

Check Information

Group: Rec. 04. Integers (INT)

See Also

External Websites

INT07-C

Introduced in R2019a

CERT C: Rec. INT08-C

Verify that all integer values are in range

Description

Rule Definition

Verify that all integer values are in range.

Examples

Integer overflow

Description

Integer overflow occurs when an operation on integer variables can result in values that cannot be represented by the result data type. The data type of a variable determines the number of bytes allocated for the variable storage and constrains the range of allowed values.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Integer overflows on signed integers result in undefined behavior.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variables in the overflowing computation acquire their current values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace

back using right-click options in the source code and see previous related events. See also .

You can fix the defect by:

- Using a bigger data type for the result of the operation so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

To avoid overflows in general, try one of these techniques:

- Keep integer variable values restricted to within half the range of signed integers.
- In operations that might overflow, check for conditions that can lead to the overflow and implement wrap around or saturation behavior depending on how the result of the operation is used. The result then becomes predictable and can be safely used in subsequent computations.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Addition of Maximum Integer

```
#include <limits.h>

int plusplus(void) {

    int var = INT_MAX;
    var++;
    return var;
}
```

In the third statement of this function, the variable `var` is increased by one. But the value of `var` is the maximum integer value, so an `int` cannot represent one plus the maximum integer value.

Correction — Different Storage Type

One possible correction is to change data types. Store the result of the operation in a larger data type (Note that on a 32-bit machine, `int` and `long` has the same size). In this

example, on a 32-bit machine, by returning a `long long` instead of an `int`, the overflow error is fixed.

```
#include <limits.h>

long long plusplus(void) {

    long long lvar = INT_MAX;
    lvar++;
    return lvar;
}
```

Integer constant overflow

Description

Integer constant overflow occurs when you assign a compile-time constant to a signed integer variable whose data type cannot accommodate the value. An `n`-bit signed integer holds values in the range $[-2^{n-1}, 2^{n-1}-1]$.

For instance, `c` is an 8-bit signed `char` variable that cannot hold the value 255.

```
signed char c = 255;
```

To determine the sizes of fundamental types, Bug Finder uses your specification for `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

The default behavior for constant overflows can vary between compilers and platforms. Retaining constant overflows can reduce the portability of your code.

Even if your compilers wraps around overflowing constants with a warning, the wrap-around behavior can be unintended and cause unexpected results.

Fix

Check if the constant value is what you intended. If the value is correct, use a different, possibly wider, data type for the variable.

Example - Overflowing Constant from Macro Expansion

```
#define MAX_UNSIGNED_CHAR 255
#define MAX_SIGNED_CHAR 127

void main() {
    char c1 = MAX_UNSIGNED_CHAR;
    char c2 = MAX_SIGNED_CHAR+1;
}
```

In this example, the defect appears on the macros because at least one use of the macro causes an overflow. To reproduce these defects, use a `Target processor type (-target)` where `char` is signed by default. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Correction — Use Different Data Type

One possible correction is to use a different data type for the variables that overflow.

```
#define MAX_UNSIGNED_CHAR 255
#define MAX_SIGNED_CHAR 127

void main() {
    unsigned char c1 = MAX_UNSIGNED_CHAR;
    unsigned char c2 = MAX_SIGNED_CHAR+1;
}
```

Check Information

Group: Rec. 04. Integers (INT)

See Also

External Websites

INT08-C

Introduced in R2019a

CERT C: Rec. INT09-C

Ensure enumeration constants map to unique values

Description

Rule Definition

Ensure enumeration constants map to unique values.

Examples

Enumeration constants map to same value

Description

The issue occurs when, within an enumerator list, the value of an implicitly-specified enumeration constants are not unique.

The rule checker flags an enumeration if it has an implicitly specified enumeration constant with the same value as another enumeration constant.

Risk

An implicitly specified enumeration constant has a value one greater than its predecessor. If the first enumeration constant is implicitly specified, then its value is 0. An explicitly specified enumeration constant has the specified value.

If implicitly and explicitly specified constants are mixed within an enumeration list, it is possible for your program to replicate values. Such replications can be unintentional and can cause unexpected behavior.

Example - Replication of Value in Implicitly Specified Enum Constants

```
enum color1 {red_1, blue_1, green_1};   /* Compliant */
enum color2 {red_2 = 1, blue_2 = 2, green_2 = 3};       /* Compliant */
```

```
enum color3 {red_3 = 1, blue_3, green_3};     /* Compliant */
enum color4 {red_4, blue_4, green_4 = 1};     /* Non Compliant */
enum color5 {red_5 = 2, blue_5, green_5 = 2};     /* Compliant */
enum color6 {red_6 = 2, blue_6, green_6 = 2, yellow_6};     /* Non Compliant */
```

Compliant situations:

- `color1`: All constants are implicitly specified.
- `color2`: All constants are explicitly specified.
- `color3`: Though there is a mix of implicit and explicit specification, all constants have unique values.
- `color5`: The implicitly specified constants have unique values.

Noncompliant situations:

- `color4`: The implicitly specified constant `blue_4` has the same value as `green_4`.
- `color6`: The implicitly specified constant `blue_6` has the same value as `yellow_6`.

Check Information

Group: Rec. 04. Integers (INT)

See Also

External Websites

INT09-C

Introduced in R2019a

CERT C: Rec. INT10-C

Do not assume a positive remainder when using the % operator

Description

Rule Definition

Do not assume a positive remainder when using the % operator.

Examples

Tainted modulo operand

Description

Tainted modulo operand checks the operands of remainder `%` operations. Bug Finder flags modulo operations with one or more tainted operands.

Risk

- If the second remainder operand is zero, your remainder operation fails, causing your program to crash.
- If the second remainder operand is `-1`, your remainder operation can overflow if the remainder operation is implemented based on the division operation that can overflow.
- If one of the operands is negative, the operation result is uncertain. For C89, the modulo operation is not standardized, so the result from negative operands is implementation-defined.

These risks can be exploited by attackers to gain access to your program or the target in general.

Fix

Before performing the modulo operation, validate the values of the operands. Check the second operand for values of `0` and `-1`. Check both operands for negative values.

Example - Modulo with Function Arguments

```
extern void print_int(int);

int taintedintmod(int userden) {
    int rem =  128%userden;
    print_int(rem);
    return rem;
}
```

In this example, the function performs a modulo operation by using an input argument. The argument is not checked before calculating the remainder for values that can crash the program, such as 0 and -1.

Correction — Check Operand Values

One possible correction is to check the values of the operands before performing the modulo operation. In this corrected example, the modulo operation continues only if the second operand is greater than zero.

```
extern void print_int(int);

int taintedintmod(int userden) {
    int rem = 0;
    if (userden > 0) {
        rem = 128 % userden;
    }
    print_int(rem);
    return rem;
}
```

Check Information

Group: Rec. 04. Integers (INT)

See Also

External Websites

INT10-C

Introduced in R2019a

CERT C: Rec. INT12-C

Do not make assumptions about the type of a plain int bit-field when used in an expression

Description

Rule Definition

Do not make assumptions about the type of a plain int bit-field when used in an expression.

Examples

Bit-field declared without appropriate type

Description

The issue occurs when you declare a bit-filed without an appropriate type.

Risk

Using `int` is implementation-defined because bit-fields of type `int` can be either `signed` or `unsigned`.

The use of `enum`, `short char`, or any other type of bit-field is not permitted in C90 because the behavior is undefined.

In C99, the implementation can potentially define other integer types that are permitted in bit-field declarations.

Check Information

Group: Rec. 04. Integers (INT)

See Also

External Websites

INT12-C

Introduced in R2019a

CERT C: Rec. INT13-C

Use bitwise operators only on unsigned operands

Description

Rule Definition

Use bitwise operators only on unsigned operands.

Examples

Bitwise operation on negative value

Description

Bitwise operation on negative value detects bitwise operators (>>, ^, |, ~, `but`, `not`, &) used on signed integer variables with negative values.

Risk

If the value of the signed integer is negative, bitwise operation results can be unexpected because:

- Bitwise operations on negative values are compiler-specific.
- Unexpected calculations can lead to additional vulnerabilities, such as buffer overflow.

Fix

When performing bitwise operations, use `unsigned` integers to avoid unexpected results.

Example - Right-Shift of Negative Integer

```
#include <stdio.h>
#include <stdarg.h>
```

```
static void demo_sprintf(const char *format, ...)
{
    int rc;
    va_list ap;
    char buf[sizeof("256")];

    va_start(ap, format);
    rc = vsprintf(buf, format, ap);
    if (rc == -1 || rc >= sizeof(buf)) {
        /* Handle error */
    }
    va_end(ap);
}

void bug_bitwiseneg()
{
    int stringify = 0x80000000;
    demo_sprintf("%u", stringify >> 24);
}
```

In this example, the statement `demo_sprintf("%u", stringify >> 24)` stops the program unexpectedly. You expect the result of `stringify >> 24` to be `0x80`. However, the actual result is `0xffffff80` because `stringify` is signed and negative. The sign bit is also shifted.

Correction — Add `unsigned` Keyword

By adding the `unsigned` keyword, `stringify` is not negative and the right-shift operation gives the expected result of `0x80`.

```
#include <stdio.h>
#include <stdarg.h>

static void demo_sprintf(const char *format, ...)
{
    int rc;
    va_list ap;
    char buf[sizeof("256")];

    va_start(ap, format);
    rc = vsprintf(buf, format, ap);
    if (rc == -1 || rc >= sizeof(buf)) {
        /* Handle error */
    }
```

```
    va_end(ap);
}

void corrected_bitwiseneg()
{
    unsigned int stringify = 0x80000000;
    demo_sprintf("%u", stringify >> 24);
}
```

Check Information

Group: Rec. 04. Integers (INT)

See Also

External Websites

INT13-C

Introduced in R2019a

CERT C: Rec. INT14-C

Avoid performing bitwise and arithmetic operations on the same data

Description

Rule Definition

Avoid performing bitwise and arithmetic operations on the same data.

Examples

Bitwise and arithmetic operation on the same data

Description

Bitwise and arithmetic operation on a same data detects statements with bitwise and arithmetic operations on the same variable or expression.

Risk

Mixed bitwise and arithmetic operations *do* compile. However, the size of integer types affects the result of these mixed operations. Mixed operations also reduce readability and maintainability.

Fix

Separate bitwise and arithmetic operations, or use only one type of operation per statement.

Example - Shift and Addition

```
unsigned int bitwisearithmix()
{
    unsigned int var = 50;
    var += (var << 2) + 1;
```

```
    return var;
}
```

This example shows bitwise and arithmetic operations on the variable `var`. `var` is shifted by two (bitwise), then increased by 1 and added to itself (arithmetic).

Correction — Arithmetic Operations Only

You can reduce this expression to arithmetic-only operations: `var + (var << 2)` is equivalent to `var * 5`.

```
unsigned int bitwisearithmix()
{
    unsigned int var = 50;
    var = var * 5 +1;
    return var;
}
```

Check Information

Group: Rec. 04. Integers (INT)

See Also

External Websites

INT14-C

Introduced in R2019a

CERT C: Rec. INT18-C

Evaluate integer expressions in a larger size before comparing or assigning to that size

Description

Rule Definition

Evaluate integer expressions in a larger size before comparing or assigning to that size.

Examples

Integer overflow

Description

Integer overflow occurs when an operation on integer variables can result in values that cannot be represented by the result data type. The data type of a variable determines the number of bytes allocated for the variable storage and constrains the range of allowed values.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Integer overflows on signed integers result in undefined behavior.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variables in the overflowing computation acquire their current values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace

back using right-click options in the source code and see previous related events. See also .

You can fix the defect by:

- Using a bigger data type for the result of the operation so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

To avoid overflows in general, try one of these techniques:

- Keep integer variable values restricted to within half the range of signed integers.
- In operations that might overflow, check for conditions that can lead to the overflow and implement wrap around or saturation behavior depending on how the result of the operation is used. The result then becomes predictable and can be safely used in subsequent computations.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Addition of Maximum Integer

```
#include <limits.h>

int plusplus(void) {

    int var = INT_MAX;
    var++;
    return var;
}
```

In the third statement of this function, the variable `var` is increased by one. But the value of `var` is the maximum integer value, so an `int` cannot represent one plus the maximum integer value.

Correction — Different Storage Type

One possible correction is to change data types. Store the result of the operation in a larger data type (Note that on a 32-bit machine, `int` and `long` has the same size). In this

example, on a 32-bit machine, by returning a `long long` instead of an `int`, the overflow error is fixed.

```
#include <limits.h>

long long plusplus(void) {

    long long lvar = INT_MAX;
    lvar++;
    return lvar;
}
```

Unsigned integer overflow

Description

Unsigned integer overflow occurs when an operation on unsigned integer variables can result in values that cannot be represented by the result data type. The data type of a variable determines the number of bytes allocated for the variable storage and constrains the range of allowed values.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

The C11 standard states that unsigned integer overflows result in wrap-around behavior. However, a wrap around behavior might not always be desirable. For instance, if the result of a computation is used as an array size and the computation overflows, the array size is much smaller than expected.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

You can fix the defect by:

- Using a bigger data type for the result of the operation so that all values can be accommodated.

- Checking for values that lead to the overflow and performing appropriate error handling. In the error handling code, you can override the default wrap-around behavior for overflows and implement saturation behavior, for instance.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Add One to Maximum Unsigned Integer

```
#include <limits.h>

unsigned int plusplus(void) {

    unsigned uvar = UINT_MAX;
    uvar++;
    return uvar;
}
```

In the third statement of this function, the variable `uvar` is increased by 1. However, the value of `uvar` is the maximum unsigned integer value, so 1 plus the maximum integer value cannot be represented by an `unsigned int`. The C programming language standard does not view unsigned overflow as an error because the program automatically reduces the result by modulo the maximum value plus 1. In this example, `uvar` is reduced by modulo `UINT_MAX`. The result is `uvar = 1`.

Correction — Different Storage Type

One possible correction is to store the operation result in a larger data type. In this example, by returning an `unsigned long long` instead of an `unsigned int`, the overflow error is fixed.

```
#include <limits.h>

unsigned long long plusplus(void) {

    unsigned long long ullvar = UINT_MAX;
    ullvar++;
    return ullvar;
}
```

Check Information

Group: Rec. 04. Integers (INT)

See Also

External Websites

INT18-C

Introduced in R2019a

Rec. 05. Floating Point (FLP)

CERT C: Rec. FLP00-C

Understand the limitations of floating-point numbers

Description

Rule Definition

Understand the limitations of floating-point numbers.

Examples

Absorption of float operand

Description

Absorption of float operand occurs when one operand of an addition or subtraction operation is *always* negligibly small compared to the other operand. Therefore, the result of the operation is always equal to the value of the larger operand, making the operation redundant.

Risk

Redundant operations waste execution cycles of your processor.

The absorption of a float operand can indicate design issues elsewhere in the code. It is possible that the developer expected a different range for one of the operands and did not expect the redundancy of the operation. However, the operand range is different from what the developer expects because of issues elsewhere in the code.

Fix

See if the operand ranges are what you expect. To see the ranges, place your cursor on the operation.

- If the ranges are what you expect, justify why you have the redundant operation in place. For instance, the code is only partially written and you anticipate other values for one or both of the operands from future unwritten code.

  If you cannot justify the redundant operation, remove it.
- If the ranges are not what you expect, in your code, trace back to see where the ranges come from. To begin your traceback, search for instances of the operand in your code. Browse through previous instances of the operand and determine where the unexpected range originates.

To determine when one operand is negligible compared to the other operand, the defect uses rules based on IEEE 754 standards. To fix the defect, instead of using the actual rules, you can use this heuristic: the ratio of the larger to the smaller operand must be less than 2^{p-1} at least for some values. Here, p is equal to 24 for 32-bit precision and 53 for 64-bit precision. To determine the precision, the defect uses your specification for `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

This defect appears only if one operand is *always* negligibly smaller than the other operand. To see instances of subnormal operands or results, use the check **Subnormal Float** in Polyspace Code Prover.

Example - One Addition Operand Negligibly Smaller Than The Other Operand

```
#include <stdlib.h>

float get_signal(void);
void do_operation(float);

float input_signal1(void) {
    float temp = get_signal();
    if(temp > 0. && temp < 1e-30)
        return temp;
    else {
       /* Reject value */
       exit(EXIT_FAILURE);
    }
}

float input_signal2(void) {
    float temp = get_signal();
    if(temp > 1.)
        return temp;
```

```
    else {
       /* Reject value */
       exit(EXIT_FAILURE);
    }
}

void main() {
    float signal1 = input_signal1();
    float signal2 = input_signal2();
    float super_signal = signal1 + signal2;
    do_operation(super_signal);
}
```

In this example, the defect appears on the addition because the operand `signal1` is in the range `(0,1e-30)` but `signal2` is greater than `1`.

Correction — Remove Redundant Operation

One possible correction is to remove the redundant addition operation. In the following corrected code, the operand `signal2` and its associated code is also removed from consideration.

```
#include <stdlib.h>

float get_signal(void);
void do_operation(float);

float input_signal1(void) {
    float temp = get_signal();
    if(temp > 0. && temp < 1e-30)
        return temp;
    else {
       /* Reject value */
       exit(EXIT_FAILURE);
    }
}

void main() {
    float signal1 = input_signal1();
    do_operation(signal1);
}
```

Correction — Verify Operand Range

Another possible correction is to see if the operand ranges are what you expect. For instance, if one of the operand range is not supposed to be negligibly small, fix the issue causing the small range. In the following corrected code, the range `(0,1e-2)` is imposed on `signal2` so that it is not *always* negligibly small as compared to `signal1`.

```
#include <stdlib.h>

float get_signal(void);
void do_operation(float);

float input_signal1(void) {
    float temp = get_signal();
    if(temp > 0. && temp < 1e-2)
        return temp;
    else {
       /* Reject value */
       exit(EXIT_FAILURE);
    }
}

float input_signal2(void) {
    float temp = get_signal();
    if(temp > 1.)
        return temp;
    else {
       /* Reject value */
       exit(EXIT_FAILURE);
    }
}

void main() {
    float signal1 = input_signal1();
    float signal2 = input_signal2();
    float super_signal = signal1 + signal2;
    do_operation(super_signal);
}
```

Check Information

Group: Rec. 05. Floating Point (FLP)

See Also

External Websites

FLP00-C

Introduced in R2019a

CERT C: Rec. FLP02-C

Avoid using floating-point numbers when precise computation is needed

Description

Rule Definition

Avoid using floating-point numbers when precise computation is needed.

Examples

Floating point comparison with equality operators

Description

Floating point comparison with equality operators occurs when you use an equality (==) or inequality (!=) operation with floating-point numbers.

Polyspace does not raise a defect for an equality or inequality operation with floating-point numbers when:

- The comparison is between two float constants.

  ```
  float flt = 1.0;
  if (flt == 1.1)
  ```

- The comparison is between a constant and a variable that can take a finite, reasonably small number of values.

  ```
  float x;

  int rand = random();
  switch(rand) {
  case 1: x = 0.0; break;
  case 2: x = 1.3; break;
  case 3: x = 1.7; break;
  ```

```
case 4: x = 2.0; break;
default: x = 3.5; break; }
…
if (x==1.3)
```

- The comparison is between floating-point expressions that contain only integer values.

```
float x = 0.0;
for (x=0.0;x!=100.0;x+=1.0) {
…
if (random) break;
}

if (3*x+4==2*x-1)
…
if (3*x+4 == 1.3)
```

- One of the operands is `0.0`, unless you use the option flag `-detect-bad-float-op-on-zero`.

```
/* Defect detected when
you use the option flag */

if (x==0.0f)
```

If you are running an analysis through the user interface, you can enter this option in the **Other** field, under the **Advanced Settings** node on the **Configuration** pane. See `Other`. For more information on this analysis option, see the documentation for Polyspace Bug Finder.

At the command line, add the flag to your analysis command.

```
polyspace-bug-finder -sources filename ^
-checkers BAD_FLOAT_OP -detect-bad-float-op-on-zero
```

Risk

Checking for equality or inequality of two floating-point values might return unexpected results because floating-point representations are inexact and involve rounding errors.

Fix

Instead of checking for equality of floating-point values:

```
if (val1 == val2)
```

check if their difference is less than a predefined tolerance value (for instance, the value `FLT_EPSILON` defined in `float.h`):

```
#include <float.h>
if(fabs(val1-val2) < FLT_EPSILON)
```

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Floats Inequality in `for`-loop

```
#include <stdio.h>
#include <math.h>
#include <float.h>

void func(void)
{
    float f;
    for (f = 1.0; f != 2.0; f = f + 0.1)
        (void)printf("Value: %f\n", f);
}
```

In this function, the `for`-loop tests the inequality of `f` and the number 2.0 as a stopping mechanism. The number of iterations is difficult to determine, or might be infinite, because of the imprecision in floating-point representation.

Correction — Change the Operator

One possible correction is to use a different operator that is not as strict. For example, an inequality like >= or <=.

```
#include <stdio.h>
#include <math.h>
#include <float.h>

void func(void)
{
    float f;
    for (f = 1.0; f <= 2.0; f = f + 0.1)
        (void)printf("Value: %f\n", f);
}
```

Check Information

Group: Rec. 05. Floating Point (FLP)

See Also

External Websites

FLP02-C

Introduced in R2019a

CERT C: Rec. FLP03-C

Detect and handle floating-point errors

Description

Rule Definition

Detect and handle floating-point errors.

Examples

Float conversion overflow

Description

Float conversion overflow occurs when converting a floating point number to a smaller floating point data type. If the variable does not have enough memory to represent the original number, the conversion overflows.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Overflows can result in unpredictable values from computations. The result can be infinity or the maximum finite value depending on the rounding mode used in the implementation. If you use the result of an overflowing conversion in subsequent computations and do not account for the overflow, you can see unexpected results.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variable being converted acquires its current value You can implement the fix on any event in the

sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

You can fix the defect by:

- Using a bigger data type for the result of the conversion so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

In general, avoid conversions to smaller floating point types.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Converting from `double` to `float`

```
float convert(void) {

    double diam = 1e100;
    return (float)diam;
}
```

In the return statement, the variable `diam` of type double (64 bits) is converted to a variable of type float (32 bits). However, the value 1^100 requires more than 32 bits to be precisely represented.

Float overflow

Description

Float overflow occurs when an operation on floating point variables can result in values that cannot be represented by the result data type. The data type of a variable determines the number of bytes allocated for the variable storage and constrains the range of allowed values.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Overflows can result in unpredictable values from computations. The result can be infinity or the maximum finite value depending on the rounding mode used in the implementation. If you use the result of an overflowing computation in subsequent computations and do not account for the overflow, you can see unexpected results.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variables in the overflowing computation acquire their current values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, for instance, when you handle infinities in your code, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Multiplication of Floats

```
#include <float.h>

float square(void) {

   float val = FLT_MAX;
   return val * val;
}
```

In the return statement, the variable `val` is multiplied by itself. The square of the maximum float value cannot be represented by a float (the return type for this function) because the value of `val` is the maximum float value.

Correction — Different Storage Type

One possible correction is to store the result of the operation in a larger data type. In this example, by returning a `double` instead of a `float`, the overflow defect is fixed.

```
#include <float.h>
```

```
double square(void) {
    float val = FLT_MAX;

    return (double)val * (double)val;
}
```

Float division by zero

Description

Float division by zero occurs when the denominator of a division operation can be a zero-valued floating point number.

Risk

A division by zero can result in a program crash.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the denominator variable acquires a zero value. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

It is a good practice to check for zero values of a denominator before division and handle the error. Instead of performing the division directly:

```
res = num/den;
```

use a library function that handles zero values of the denominator before performing the division:

```
res = div(num, den);
```

See examples of fixes below.

If you do not want to fix the issue, for instance, when you handle infinities in your code, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Dividing a Floating Point Number by Zero

```
float fraction(float num)
{
    float denom = 0.0;
    float result = 0.0;

    result = num/denom;

    return result;
}
```

A division by zero error occurs at `num/denom` because `denom` is zero.

Correction — Check Before Division

```
float fraction(float num)
{
    float denom = 0.0;
    float result = 0.0;

    if( ((int)denom) != 0)
        result = num/denom;

    return result;
}
```

Before dividing, add a test to see if the denominator is zero, checking before division occurs. If `denom` is always zero, this correction can produce a dead code defect in your Polyspace results.

Correction — Change Denominator

One possible correction is to change the denominator value so that `denom` is not zero.

```
float fraction(float num)
{
    float denom = 2.0;
    float result = 0.0;

    result = num/denom;

    return result;
}
```

Check Information

Group: Rec. 05. Floating Point (FLP)

See Also

External Websites

FLP03-C

Introduced in R2019a

CERT C: Rec. FLP06-C

Convert integers to floating point for floating-point operations

Description

Rule Definition

Convert integers to floating point for floating-point operations.

Examples

Float overflow

Description

Float overflow occurs when an operation on floating point variables can result in values that cannot be represented by the result data type. The data type of a variable determines the number of bytes allocated for the variable storage and constrains the range of allowed values.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Overflows can result in unpredictable values from computations. The result can be infinity or the maximum finite value depending on the rounding mode used in the implementation. If you use the result of an overflowing computation in subsequent computations and do not account for the overflow, you can see unexpected results.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variables in the

overflowing computation acquire their current values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, for instance, when you handle infinities in your code, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Multiplication of Floats

```
#include <float.h>

float square(void) {

   float val = FLT_MAX;
   return val * val;
}
```

In the return statement, the variable `val` is multiplied by itself. The square of the maximum float value cannot be represented by a float (the return type for this function) because the value of `val` is the maximum float value.

Correction — Different Storage Type

One possible correction is to store the result of the operation in a larger data type. In this example, by returning a `double` instead of a `float`, the overflow defect is fixed.

```
#include <float.h>

double square(void) {
    float val = FLT_MAX;

    return (double)val * (double)val;
}
```

Check Information

Group: Rec. 05. Floating Point (FLP)

See Also

External Websites

FLP06-C

Introduced in R2019a

Rec. 06. Arrays (ARR)

CERT C: Rec. ARR01-C

Do not apply the sizeof operator to a pointer when taking the size of an array

Description

Rule Definition

Do not apply the sizeof operator to a pointer when taking the size of an array.

Examples

Wrong type used in sizeof

Description

Wrong type used in sizeof occurs when both of the following conditions hold:

- You assign the address of a block of memory to a pointer, or transfer data between two blocks of memory. The assignment or copy uses the `sizeof` operator.

  For instance, you initialize a pointer using `malloc(sizeof(`*`type`*`))` or copy data between two addresses using `memcpy(`*`destination_ptr`*`, `*`source_ptr`*`, sizeof(`*`type`*`))`.
- You use an incorrect type as argument of the `sizeof` operator. You use the pointer type instead of the type that the pointer points to.

  For instance, to initialize a *`type`*`*` pointer, you use `malloc(sizeof(`*`type`*`*`))` instead of `malloc(sizeof(`*`type`*`))`.

Risk

Irrespective of what *`type`* stands for, the expression `sizeof(`*`type`*`*`)` always returns a fixed size. The size returned is the pointer size on your platform in bytes. The appearance of `sizeof(`*`type`*`*`)` often indicates an unintended usage. The error can cause allocation

of a memory block that is much smaller than what you need and lead to weaknesses such as buffer overflows.

For instance, assume that `structType` is a structure with ten `int` variables. If you initialize a `structType*` pointer using `malloc(sizeof(structType*))` on a 32-bit platform, the pointer is assigned a memory block of four bytes. However, to be allocated completely for one `structType` variable, the `structType*` pointer must point to a memory block of `sizeof(structType) = 10 * sizeof(int)` bytes. The required size is much greater than the actual allocated size of four bytes.

Fix

To initialize a *`type`*`*` pointer, replace `sizeof(`*`type`*`*)` in your pointer initialization expression with `sizeof(`*`type`*`)`.

Example - Allocate a Char Array With `sizeof`

```
#include <stdlib.h>

void test_case_1(void) {
    char* str;

    str = (char*)malloc(sizeof(char*) * 5);
    free(str);

}
```

In this example, memory is allocated for the character pointer `str` using a `malloc` of five char pointers. However, `str` is a pointer to a character, not a pointer to a character pointer. Therefore the `sizeof` argument, `char*`, is incorrect.

Correction — Match Pointer Type to `sizeof` Argument

One possible correction is to match the argument to the pointer type. In this example, `str` is a character pointer, therefore the argument must also be a character.

```
#include <stdlib.h>

void test_case_1(void) {
    char* str;

    str = (char*)malloc(sizeof(char) * 5);
    free(str);
```

```
}
```

Possible misuse of sizeof

Description

Possible misuse of sizeof occurs when Polyspace Bug Finder detects possibly unintended results from the use of `sizeof` operator. For instance:

- You use the `sizeof` operator on an array parameter name, expecting the array size. However, the array parameter name by itself is a pointer. The `sizeof` operator returns the size of that pointer.
- You use the `sizeof` operator on an array element, expecting the array size. However, the operator returns the size of the array element.
- The size argument of certain functions such as `strncmp` or `wcsncpy` is incorrect because you used the `sizeof` operator earlier with possibly incorrect expectations. For instance:
  - In a function call `strncmp(string1, string2, num)`, `num` is obtained from an incorrect use of the `sizeof` operator on a pointer.
  - In a function call `wcsncpy(destination, source, num)`, `num` is the not the number of wide characters but a size in bytes obtained by using the `sizeof` operator. For instance, you use `wcsncpy(destination, source, sizeof(destination) - 1)` instead of `wcsncpy(destination, source, (sizeof(desintation)/sizeof(wchar_t)) - 1)`.

Risk

Incorrect use of the `sizeof` operator can cause the following issues:

- If you expect the `sizeof` operator to return array size and use the return value to constrain a loop, the number of loop runs are smaller than what you expect.
- If you use the return value of `sizeof` operator to allocate a buffer, the buffer size is smaller than what you require. Insufficient buffer can lead to resultant weaknesses such as buffer overflows.
- If you use the return value of `sizeof` operator incorrectly in a function call, the function does not behave as you expect.

Fix

Possible fixes are:

- Do not use the `sizeof` operator on an array parameter name or array element to determine array size.

  The best practice is to pass the array size as a separate function parameter and use that parameter in the function body.
- Use the `sizeof` operator carefully to determine the number argument of functions such as `strncmp` or `wcsncpy`. For instance, for wide string functions such as `wcsncpy`, use the number of wide characters as argument instead of the number of bytes.

Example - `sizeof` Used Incorrectly to Determine Array Size

```
#define MAX_SIZE 1024

void func(int a[MAX_SIZE]) {
    int i;

    for (i = 0; i < sizeof(a)/sizeof(int); i++)    {
        a[i] = i + 1;
    }
}
```

In this example, `sizeof(a)` returns the size of the pointer `a` and not the array size.

Correction — Determine Array Size in Another Way

One possible correction is to use another means to determine the array size.

```
#define MAX_SIZE 1024

void func(int a[MAX_SIZE]) {
    int i;

    for (i = 0; i < MAX_SIZE; i++)    {
        a[i] = i + 1;
    }
}
```

Check Information

Group: Rec. 06. Arrays (ARR)

See Also

External Websites

ARR01-C

Introduced in R2019a

CERT C: Rec. ARR02-C

Explicitly specify array bounds, even if implicitly defined by an initializer

Description

Rule Definition

Explicitly specify array bounds, even if implicitly defined by an initializer.

Examples

Size of `extern` array not specified

Description

The issue occurs when you declare an array with external linkage but you do not explicitly specify the its size.

The rule checker flags arrays declared with the `extern` specifier if the declaration does not explicitly specify the array size.

Risk

Although it is possible to declare an array with an incomplete type and access its elements, it is safer to state the size of the array explicitly. If you provide size information for each declaration, a code reviewer can check multiple declarations for their consistency. With size information, a static analysis tool can perform array bounds analysis without analyzing more than one unit.

Example - Array Declarations

```
extern int32_t array1[10];    /*  Compliant  */
extern int32_t array2[];      /*  Non-compliant  */
```

In this example, two arrays are declared `array1` and `array2`. `array1` has external linkage (the `extern` keyword) and a size of 10. `array2` also has external linkage, but no

specified size. `array2` is noncompliant because for arrays with external linkage, you must explicitly specify a size.

Array size not specified with designated initializer

Description

The issue occurs when you use designated initializers to initialize an array object but you do not explicitely specify the size of the array.

Risk

If the size of an array is not specified explicitly, it is determined by the highest index of the elements that are initialized. When using long designated initializers, it might not be immediately apparent which element has the highest index.

Example - Using Designated Initializers Without Specifying Array Size

```
int a[5] = {[0]= 1, [2] = 1, [4]= 1, [1] = 1};        /* Compliant */
int b[] = {[0]= 1, [2] = 1, [4]= 1, [1] = 1};         /* Non-compliant */
int c[] = {[0]= 1, [1] = 1, [2]= 1, [3]=0, [4] = 1};  /* Non-compliant */

void display(int);

void main() {
    func(a,5);
    func(b,5);
    func(c,5);
}

void func(int* arr, int size) {
    for(int i=0; i<size; i++)
        display(arr[i]);
}
```

In this example, the rule is violated when the arrays `b` and `c` are initialized using designated initializers but the array size is not specified.

Improper array initialization

Description

Improper array initialization occurs when Polyspace Bug Finder considers that an array initialization using initializers is incorrect.

This defect applies to normal and designated initializers. In C99, with designated initializers, you can place the elements of an array initializer in any order and implicitly initialize some array elements. The designated initializers use the array index to establish correspondence between an array element and an array initializer element. For instance, the statement `int arr[6] = { [4] = 29, [2] = 15 }` is equivalent to `int arr[6] = { 0, 0, 15, 0, 29, 0 }`.

You can use initializers incorrectly in one of the following ways.

Issue	Risk	Possible Fix
In your initializer for a one-dimensional array, you have more elements than the array size.	Unused array initializer elements indicate a possible coding error.	Increase the array size or remove excess elements.
You place the braces enclosing initializer values incorrectly.	Because of the incorrect placement of braces, some array initializer elements are not used. Unused array initializer elements indicate a possible coding error.	Place braces correctly.
In your designated initializer, you do not initialize the first element of the array explicitly.	The implicit initialization of the first array element indicates a possible coding error. You possibly overlooked the fact that array indexing starts from 0.	Initialize all elements explicitly.

Issue	Risk	Possible Fix
In your designated initializer, you initialize an element twice.	The first initialization is overridden. The redundant first initialization indicates a possible coding error.	Remove the redundant initialization.
You use designated and nondesignated initializers in the same initialization.	You or another reviewer of your code cannot determine the size of the array by inspection.	Use either designated or nondesignated initializers.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Incorrectly Placed Braces (C Only)

```
int arr[2][3]
= {{1, 2},
    {3, 4},
    {5, 6}
};
```

In this example, the array `arr` is initialized as `{1,2,0,3,4,0}`. Because the initializer contains `{5,6}`, you might expect the array to be initialized `{1,2,3,4,5,6}`.

Correction — Place Braces Correctly

One possible correction is to place the braces correctly so that all elements are explicitly initialized.

```
int a1[2][3]
= {{1, 2, 3},
    {4, 5, 6}
};
```

Example - First Element Not Explicitly Initialized

```
int arr[5]
= {
    [1] = 2,
    [2] = 3,
    [3] = 4,
    [4] = 5
};
```

In this example, `arr[0]` is not explicitly initialized. It is possible that the programmer did not consider that the array indexing starts from 0.

Correction — Explicitly Initialize All Elements

One possible correction is to initialize all elements explicitly.

```
int arr[5]
= {
    [0] = 1,
    [1] = 2,
    [2] = 3,
    [3] = 4,
    [4] = 5
};
```

Example - Element Initialized Twice

```
int arr[5]
= {
    [0] = 1,
    [1] = 2,
    [2] = 3,
    [2] = 4,
    [4] = 5
};
```

In this example, `arr[2]` is initialized twice. The first initialization is overridden. In this case, because `arr[3]` was not explicitly initialized, it is possible that the programmer intended to initialize `arr[3]` when `arr[2]` was initialized a second time.

Correction — Fix Redundant Initialization

One possible correction is to eliminate the redundant initialization.

```
int arr[5]
= {
    [0] = 1,
    [1] = 2,
    [2] = 3,
    [3] = 4,
    [4] = 5
};
```

Example - Mix of Designated and Nondesignated Initializers

```
int arr[]
= {
    [0] = 1,
    [3] = 3,
    4,
    [5] = 5,
    6
    };
```

In this example, because a mix of designated and nondesignated initializers are used, it is difficult to determine the size of `arr` by inspection.

Correction — Use Only Designated Initializers

One possible correction is to use only designated initializers for array initialization.

```
int arr[]
= {
    [0] = 1,
    [3] = 3,
    [4] = 4,
    [5] = 5,
    [6] = 6
};
```

Check Information

Group: Rec. 06. Arrays (ARR)

See Also

External Websites

ARR02-C

Introduced in R2019a

Rec. 07. Characters and Strings (STR)

CERT C: Rec. STR02-C

Sanitize data passed to complex subsystems

Description

Rule Definition

Sanitize data passed to complex subsystems.

Examples

Execution of externally controlled command

Description

Execution of externally controlled command checks for commands that are fully or partially constructed from externally controlled input.

Risk

Attackers can use the externally controlled input as operating system commands, or arguments to the application. An attacker could read or modify sensitive data can be read or modified, execute unintended code, or gain access to other aspects of the program.

Fix

Validate the inputs to allow only intended input values. For example, create a whitelist of acceptable inputs and compare the input against this list.

Example - Call Argument Command

```
#define _XOPEN_SOURCE
#define _GNU_SOURCE

#include "stdlib.h"
```

```
#include "stdio.h"
#include "string.h"
#include "unistd.h"
#include "dlfcn.h"
#include "limits.h"

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

void taintedexternalcmd(char* usercmd)
{
    char cmd[SIZE128] = "/usr/bin/cat ";
    strcat(cmd, usercmd);
    system(cmd);
}
```

This example function calls a command from a user argument without checking the command variable.

Correction — Use a Predefined Command

One possible correction is to use a `switch` statement to run a predefined command, using the user input as the switch variable.

```
#define _XOPEN_SOURCE
#define _GNU_SOURCE

#include "stdlib.h"
#include "stdio.h"
#include "string.h"
#include "unistd.h"
#include "dlfcn.h"
#include "limits.h"

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};
enum { CMD0 = 1, CMD1, CMD2 };

void taintedexternalcmd(int usercmd)
```

```
{
    char cmd[SIZE128] = "/usr/bin/cat ";

    switch(usercmd) {
        case CMD0:
            strcat(cmd, "*.c");
            break;
        case CMD1:
            strcat(cmd, "*.h");
            break;
        case CMD2:
            strcat(cmd, "*.cpp");
            break;
        default:
            strcat(cmd, "*.c");
    }
    system(cmd);
}
```

Command executed from externally controlled path

Description

Command executed from externally controlled path checks the path of commands that the application controls. If the path of a command is from or constructed from external sources, Bug Finder flags the command function.

Risk

An attacker can:

- Change the command that the program executes, possibly to a command that only the attack can control.
- Change the environment in which the command executes, by which the attacker controls what the command means and does.

Fix

Before calling the command, validate the path to make sure that it is the intended location.

Example - Executing Path from Environment Variable

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

void bug_taintedpathcmd() {
    char cmd[SIZE128] = "";
    char* userpath = getenv("MYAPP_PATH");

    strncpy(cmd, userpath, SIZE100);
    strcat(cmd, "/ls *");
    /* Launching command */
    system(cmd);
}
```

This example obtains a path from an environment variable `MYAPP_PATH`. `system` runs a command from that path without checking the value of the path. If the path is not the intended path, your program executes in the wrong location.

Correction — Use Trusted Path

One possible correction is to use a list of allowed paths to match against the environment variable path.

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

/* Function to sanitize a string */
int sanitize_str(char* s, size_t n) {
    int res = 0;
```

```
    /* String is ok if */
    if (s && n>0 && n<SIZE128) {
        /* - string is not null                      */
        /* - string has a positive and limited size */
        s[n-1] = '\0';  /* Add a security \0 char at end of string */
        /* Tainted pointer detected above, used as "firewall" */
        res = 1;
    }
    return res;
}

/* Authorized path ids */
enum { PATH0=1, PATH1, PATH2 };

void taintedpathcmd() {
    char cmd[SIZE128] = "";

    char* userpathid = getenv("MYAPP_PATH_ID");
    if (sanitize_str(userpathid, SIZE100)) {
        int pathid = atoi(userpathid);


        char path[SIZE128] = "";
        switch(pathid) {
            case PATH0:
                strcpy(path, "/usr/local/my_app0");
                break;
            case PATH1:
                strcpy(path, "/usr/local/my_app1");
                break;
            case PATH2:
                strcpy(path, "/usr/local/my_app2");
                break;
            default:
                /* do nothing */
        break;
        }
        if (strlen(path)>0) {
            strncpy(cmd, path, SIZE100);
            strcat(cmd, "/ls *");
            system(cmd);
        }
    }
}
```

Library loaded from externally controlled path

Description

Library loaded from externally controlled path looks for libraries loaded from fixed or controlled paths. If unintended actors can control one or more locations on this fixed path, Bug Finder raises a defect.

Risk

If an attacker knows or controls the path that you use to load a library, the attacker can change:

- The library that the program loads, replacing the intended library and commands.
- The environment in which the library executes, giving unintended permissions and capabilities to the attacker.

Fix

When possible, use hard-coded or fully qualified path names to load libraries. It is possible the hard-coded paths do not work on other systems. Use a centralized location for hard-coded paths, so that you can easily modify the path within the source code.

Another solution is to use functions that require explicit paths. For example, `system()` does not require a full path because it can use the `PATH` environment variable. However, `execl()` and `execv()` do require the full path.

Example - Call Custom Library

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include <unistd.h>
#include <dlfcn.h>
#include <limits.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

void* taintedpathlib() {
```

```
    void* libhandle = NULL;
    char lib[SIZE128] = "";
    char* userpath = getenv("LD_LIBRARY_PATH");
    strncpy(lib, userpath, SIZE128);
    strcat(lib, "/libX.so");
    libhandle = dlopen(lib, 0x00001);
    return libhandle;
}
```

This example loads the library `libX.so` from an environment variable `LD_LIBRARY_PATH`. An attacker can change the library path in this environment variable. The actual library you load could be a different library from the one that you intend.

Correction — Change and Check Path

One possible correction is to change how you get the library path and check the path of the library before opening the library. This example receives the path as an input argument. Then the path is checked to make sure the library is not under `/usr/`.

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include <unistd.h>
#include <dlfcn.h>
#include <limits.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

/* Function to sanitize a string */
int sanitize_str(char* s, size_t n) {
    /* strlen is used here as a kind of firewall for tainted string errors */
    int res = (strlen(s) > 0 && strlen(s) < n);
    return res;
}
void* taintedpathlib(char* userpath) {
    void* libhandle = NULL;
    if (sanitize_str(userpath, SIZE128)) {
        char lib[SIZE128] = "";

        if (strncmp(userpath, "/usr", 4)!=0) {
```

```
            strncpy(lib, userpath, SIZE128);
            strcat(lib, "/libX.so");
            libhandle = dlopen(lib, RTLD_LAZY);
        }
    }
    return libhandle;
}
```

Check Information

Group: Rec. 07. Characters and Strings (STR)

See Also

External Websites

STR02-C

Introduced in R2019a

CERT C: Rec. STR03-C

Do not inadvertently truncate a string

Description

Rule Definition

Do not inadvertently truncate a string.

Examples

Invalid use of standard library string routine

Description

Invalid use of standard library string routine occurs when a string library function is called with invalid arguments.

Risk

The risk depends on the type of invalid arguments. For instance, using the `strcpy` function with a source argument larger than the destination argument can result in buffer overflows.

Fix

The fix depends on the standard library function involved in the defect. In some cases, you can constrain the function arguments before the function call. For instance, if the `strcpy` function:

```
char * strcpy(char * destination, const char* source)
```

tries to copy too many bytes into the destination argument compared to the available buffer, constrain the source argument before the call to `strcpy`. In some cases, you can use an alternative function to avoid the error. For instance, instead of `strcpy`, you can use `strncpy` to control the number of bytes copied. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Invalid Use of Standard Library String Routine Error

```
#include <string.h>
#include <stdio.h>

char* Copy_String(void)
{
 char *res;
 char gbuffer[5],text[20]="ABCDEFGHIJKL";

 res=strcpy(gbuffer,text);
 /* Error: Size of text is less than gbuffer */

 return(res);
}
```

The string `text` is larger in size than `gbuffer`. Therefore, the function `strcpy` cannot copy `text` into `gbuffer`.

Correction — Use Valid Arguments

One possible correction is to declare the destination string `gbuffer` with equal or larger size than the source string `text`.

```
#include <string.h>
#include <stdio.h>

char* Copy_String(void)
{
 char *res;
 /*Fix: gbuffer has equal or larger size than text */
 char gbuffer[20],text[20]="ABCDEFGHIJKL";

 res=strcpy(gbuffer,text);

 return(res);
}
```

Check Information

Group: Rec. 07. Characters and Strings (STR)

See Also

External Websites

STR03-C

Introduced in R2019a

CERT C: Rec. STR07-C

Use the bounds-checking interfaces for string manipulation

Description

Rule Definition

Use the bounds-checking interfaces for string manipulation.

Examples

Use of dangerous standard function

Description

The **Use of dangerous standard function** check highlights uses of functions that are inherently dangerous or potentially dangerous given certain circumstances. The following table lists possibly dangerous functions, the risks of using each function, and what function to use instead.

Dangerous Function	Risk Level	Safer Function
`gets`	Inherently dangerous — You cannot control the length of input from the console.	`fgets`
`cin`	Inherently dangerous — You cannot control the length of input from the console.	Avoid or prefaces calls to `cin` with `cin.width`.
`strcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`strncpy`

Dangerous Function	Risk Level	Safer Function
`stpcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`stpncpy`
`lstrcpy` or `StrCpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`StringCbCopy`, `StringCchCopy`, `strncpy`, `strcpy_s`, or `strlcpy`
`strcat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`strncat`, `strlcat`, or `strcat_s`
`lstrcat` or `StrCat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`StringCbCat`, `StringCchCat`, `strncay`, `strcat_s`, or `strlcat`
`wcpcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`wcpncpy`
`wcscat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`wcsncat`, `wcslcat`, or `wcncat_s`
`wcscpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`wcsncpy`
`sprintf`	Possibly dangerous — If the output length depends on unknown lengths or values, buffer overflow can occur.	`snprintf`

Dangerous Function	Risk Level	Safer Function
`vsprintf`	Possibly dangerous — If the output length depends on unknown lengths or values, buffer overflow can occur.	`vsnprintf`

Risk

These functions can cause buffer overflow, which attackers can use to infiltrate your program.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Using `sprintf`

```
#include <stdio.h>
#include <string.h>
#include <iostream>

#define BUFF_SIZE 128


int dangerous_func(char *str)
{
    char dst[BUFF_SIZE];
    int r = 0;

    if (sprintf(dst, "%s", str) == 1)
    {
        r += 1;
        dst[BUFF_SIZE-1] = '\0';
    }
```

```
    return r;
}
```

This example function uses `sprintf` to copy the string `str` to `dst`. However, if `str` is larger than the buffer, `sprintf` can cause buffer overflow.

Correction — Use `snprintf` with Buffer Size

One possible correction is to use `snprintf` instead and specify a buffer size.

```
#include <stdio.h>
#include <string.h>
#include <iostream>

#define BUFF_SIZE 128


int dangerous_func(char *str)
{
    char dst[BUFF_SIZE];
    int r = 0;

    if (snprintf(dst, sizeof(dst), "%s", str) == 1)
    {
        r += 1;
        dst[BUFF_SIZE-1] = '\0';
    }

    return r;
}
```

Destination buffer overflow in string manipulation

Description

Destination buffer overflow in string manipulation occurs when certain string manipulation functions write to their destination buffer argument at an offset greater than the buffer size.

For instance, when calling the function `sprintf(char* buffer, const char* format)`, you use a constant string `format` of greater size than `buffer`.

Risk

Buffer overflow can cause unexpected behavior such as memory corruption or stopping your system. Buffer overflow also introduces the risk of code injection.

Fix

One possible solution is to use alternative functions to constrain the number of characters written. For instance:

- If you use `sprintf` to write formatted data to a string, use `snprintf`, `_snprintf` or `sprintf_s` instead to enforce length control. Alternatively, use `asprintf` to automatically allocate the memory required for the destination buffer.
- If you use `vsprintf` to write formatted data from a variable argument list to a string, use `vsnprintf` or `vsprintf_s` instead to enforce length control.
- If you use `wcscpy` to copy a wide string, use `wcsncpy`, `wcslcpy`, or `wcscpy_s` instead to enforce length control.

Another possible solution is to increase the buffer size.

Example - Buffer Overflow in `sprintf` Use

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";

    sprintf(buffer, fmt_string);
}
```

In this example, `buffer` can contain 20 `char` elements but `fmt_string` has a greater size.

Correction — Use `snprintf` Instead of `sprintf`

One possible correction is to use the `snprintf` function to enforce length control.

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";
```

```
    snprintf(buffer, 20, fmt_string);
}
```

Check Information

Group: Rec. 07. Characters and Strings (STR)

See Also

External Websites

STR07-C

Introduced in R2019a

CERT C: Rec. STR11-C

Do not specify the bound of a character array initialized with a string literal

Description

Rule Definition

Do not specify the bound of a character array initialized with a string literal.

Examples

Missing null in string array

Description

Missing null in string array occurs when a string does not have enough space to terminate with a null character `'\0'`.

This defect applies only for projects in C.

Risk

A buffer overflow can occur if you copy a string to an array without assuming the implicit null terminator.

Fix

If you initialize a character array with a literal, avoid specifying the array bounds.

```
char three[]  = "THREE";
```

The compiler automatically allocates space for a null terminator. In the preceding example, the compiler allocates sufficient space for five characters and a null terminator.

If the issue occurs after initialization, you might have to increase the size of the array by one to account for the null terminator.

In certain circumstances, you might want to initialize the character array with a sequence of characters instead of a string. In this situation, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Array size is too small

```
void countdown(int i)
{
    static char one[5]   = "ONE";
    static char two[5]   = "TWO";
    static char three[5] = "THREE";
}
```

The character array `three` has a size of 5 and 5 characters `'T'`, `'H'`, `'R'`, `'E'`, and `'E'`. There is no room for the null character at the end because `three` is only five bytes large.

Correction — Increase Array Size

One possible correction is to change the array size to allow for the five characters plus a null character.

```
void countdown(int i)
{
    static char one[5]   = "ONE";
    static char two[5]   = "TWO";
    static char three[6] = "THREE";
}
```

Correction — Change Initialization Method

One possible correction is to initialize the string by leaving the array size blank. This initialization method allocates enough memory for the five characters and a terminating-null character.

```
void countdown(int i)
{
    static char one[5]   = "ONE";
    static char two[5]   = "TWO";
    static char three[]  = "THREE";
}
```

Check Information

Group: Rec. 07. Characters and Strings (STR)

See Also

External Websites

STR11-C

Introduced in R2019a

Rec. 08. Memory Management (MEM)

CERT C: Rec. MEM00-C

Allocate and free memory in the same module, at the same level of abstraction

Description

Rule Definition

Allocate and free memory in the same module, at the same level of abstraction.

Examples

Invalid free of pointer

Description

Invalid free of pointer occurs when a block of memory released using the `free` function was not previously allocated using `malloc`, `calloc`, or `realloc`.

Risk

The `free` function releases a block of memory allocated on the heap. If you try to access a location on the heap that you did not allocate previously, a segmentation fault can occur.

The issue can highlight coding errors. For instance, you perhaps wanted to use the `free` function or a previous `malloc` function on a different pointer.

Fix

In most cases, you can fix the issue by removing the `free` statement. If the pointer is not allocated memory from the heap with `malloc` or `calloc`, you do not need to free the pointer. You can simply reuse the pointer as required.

If the issue highlights a coding error such as use of `free` or `malloc` on the wrong pointer, correct the error.

If the issue occurs because you use the `free` function to free memory allocated with the `new` operator, replace the `free` function with the `delete` operator.

Example - Invalid Free of Pointer Error

```
#include <stdlib.h>

void Assign_Ones(void)
{
  int p[10];
  for(int i=0;i<10;i++)
     *(p+i)=1;

  free(p);
  /* Defect: p does not point to dynamically allocated memory */
}
```

The pointer `p` is deallocated using the `free` function. However, `p` points to a memory location that was not dynamically allocated.

Correction — Remove Pointer Deallocation

If the number of elements of the array `p` is known at compile time, one possible correction is to remove the deallocation of the pointer `p`.

```
#include <stdlib.h>

void Assign_Ones(void)
 {
  int p[10];
  for(int i=0;i<10;i++)
     *(p+i)=1;
  /* Fix: Remove deallocation of p */
 }
```

Correction — Introduce Pointer Allocation

If the number of elements of the array `p` is not known at compile time, one possible correction is to dynamically allocate memory to the array `p`.

```
#include <stdlib.h>

void Assign_Ones(int num)
{
```

```
  int *p;
  /* Fix: Allocate memory dynamically to p */
  p=(int*) calloc(10,sizeof(int));
  for(int i=0;i<10;i++)
     *(p+i)=1;
  free(p);
}
```

Deallocation of previously deallocated pointer

Description

Deallocation of previously deallocated pointer occurs when a block of memory is freed more than once using the `free` function without an intermediate allocation.

Risk

When a pointer is allocated dynamic memory with `malloc`, `calloc` or `realloc`, it points to a memory location on the heap. When you use the `free` function on this pointer, the associated block of memory is freed for reallocation. Trying to free this block of memory can result in a segmentation fault.

Fix

The fix depends on the root cause of the defect. See if you intended to allocate a memory block to the pointer between the first deallocation and the second. Otherwise, remove the second `free` statement.

As a good practice, after you free a memory block, assign the corresponding pointer to NULL. Before freeing pointers, check them for NULL values and handle the error. In this way, you are protected against freeing an already freed block.

Example - Deallocation of Previously Deallocated Pointer Error

```
#include <stdlib.h>

void allocate_and_free(void)
{

    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return;

    *pi = 2;
```

```
    free(pi);
    free (pi);
    /* Defect: pi has already been freed */
}
```

The first `free` statement releases the block of memory that `pi` refers to. The second `free` statement on `pi` releases a block of memory that has been freed already.

Correction — Remove Duplicate Deallocation

One possible correction is to remove the second `free` statement.

```
#include <stdlib.h>

void allocate_and_free(void)
{

    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return;

    *pi = 2;
    free(pi);
    /* Fix: remove second deallocation */
 }
```

Use of previously freed pointer

Description

Use of previously freed pointer occurs when you access a block of memory after freeing the block using the `free` function.

Risk

When a pointer is allocated dynamic memory with `malloc`, `calloc` or `realloc`, it points to a memory location on the heap. When you use the `free` function on this pointer, the associated block of memory is freed for reallocation. Trying to access this block of memory can result in unpredictable behavior or even a segmentation fault.

Fix

The fix depends on the root cause of the defect. See if you intended to free the memory later or allocate another memory block to the pointer before access.

As a good practice, after you free a memory block, assign the corresponding pointer to NULL. Before dereferencing pointers, check them for NULL values and handle the error. In this way, you are protected against accessing a freed block.

Example - Use of Previously Freed Pointer Error

```
#include <stdlib.h>
#include <stdio.h>
 int increment_content_of_address(int base_val, int shift)
   {
    int j;
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return 0;

    *pi = base_val;
    free(pi);

    j = *pi + shift;
    /* Defect: Reading a freed pointer */

    return j;
   }
```

The `free` statement releases the block of memory that `pi` refers to. Therefore, dereferencing`pi` after the `free` statement is not valid.

Correction — Free Pointer After Use

One possible correction is to free the pointer `pi` only after the last instance where it is accessed.

```
#include <stdlib.h>

int increment_content_of_address(int base_val, int shift)
{
    int j;
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return 0;

    *pi = base_val;

    j = *pi + shift;
    *pi = 0;
```

```
    /* Fix: The pointer is freed after its last use */
    free(pi);
    return j;
}
```

Check Information

Group: Rec. 08. Memory Management (MEM)

See Also

External Websites

MEM00-C

Introduced in R2019a

CERT C: Rec. MEM01-C

Store a new value in pointers immediately after free()

Description

Rule Definition

Store a new value in pointers immediately after free().

Examples

Missing reset of a freed pointer

Description

Missing reset of a freed pointer detects pointers that have been freed and not reassigned another value. After freeing a pointer, the memory data is still accessible. To clear this data, the pointer must also be set to NULL or another value.

Risk

Not resetting pointers can cause dangling pointers. Dangling pointers can cause:

- Freeing already freed memory.
- Reading from or writing to already freed memory.
- Hackers executing code stored in freed pointers or with vulnerable permissions.

Fix

After freeing a pointer, if it is not immediately assigned to another valid address, set the pointer to NULL.

Example - Free Without Reset

```
#include <stdlib.h>
enum {
```

```
    SIZE3   = 3,
    SIZE20  = 20
};

void missingfreedptrreset()
{
    static char *str = NULL;

    if (str == NULL)
        str = (char *)malloc(SIZE20);

    if (str != NULL)
        free(str);
}
```

In this example, the pointer `str` is freed at the end of the program. The next call to `bug_missingfreedptrrese` can fail because `str` is not NULL and the initialization to NULL can be invalid.

Correction — Redefine `free` to Free and Reset

One possible correction is to customize `free` so that when you free a pointer, it is automatically reset.

```
#include <stdlib.h>
enum {
    SIZE3   = 3,
    SIZE20  = 20
};

static void sanitize_free(void **p)
{
    if ((p != NULL) && (*p != NULL))
    {
        free(*p);
        *p = NULL;
    }
}

#define free(X) sanitize_free((void **)&X)

void missingfreedptrreset()
{
    static char *str = NULL;
```

```
    if (str == NULL)
        str = (char *)malloc(SIZE20);

    if (str != ((void *)0))
    {
        free(str);
    }
}
```

Check Information

Group: Rec. 08. Memory Management (MEM)

See Also

External Websites

MEM01-C

Introduced in R2019a

CERT C: Rec. MEM02-C

Immediately cast the result of a memory allocation function call into a pointer to the allocated type

Description

Rule Definition

Immediately cast the result of a memory allocation function call into a pointer to the allocated type.

Examples

Wrong allocated object size for cast

Description

Wrong allocated object size for cast occurs during pointer conversion when the pointer's address is misaligned. If a pointer is converted to a different pointer type, the size of the allocated memory must be a multiple of the size of the destination pointer.

Risk

Dereferencing a misaligned pointer has undefined behavior and can cause your program to crash.

Fix

Suppose you convert a pointer `ptr1` to `ptr2`. If `ptr1` points to a buffer of `N` bytes and `ptr2` is a *`type`* `*` pointer where `sizeof(`*`type`*`)` is `n` bytes, make sure that `N` is an integer multiple of `n`.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Dynamic Allocation of Pointers

```
#include <stdlib.h>

void dyn_non_align(void){
    void *ptr = malloc(13);
    long *dest;

    dest = (long*)ptr; //defect
}
```

In this example, the software raises a defect on the conversion of `ptr` to a `long*`. The dynamically allocated memory of `ptr`, 13 bytes, is not a multiple of the size of `dest`, 4 bytes. This misalignment causes the **Wrong allocated object size for cast** defect.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the allocated memory to 12 instead of 13.

```
#include <stdlib.h>

void dyn_non_align(void){
    void *ptr = malloc(12);
    long *dest;

    dest = (long*)ptr;
}
```

Example - Static Allocation of Pointers

```
void static_non_align(void){
    char arr[13], *ptr;
    int *dest;

    ptr = &arr[0];
    dest = (int*)ptr; //defect
}
```

In this example, the software raises a defect on the conversion of `ptr` to an `int*` in line 6. `ptr` has a memory size of 13 bytes because the array `arr` has a size of 13 bytes. The

size of `dest` is 4 bytes, which is not a multiple of 13. This misalignment causes the **Wrong allocated object size for cast** defect.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the size of the array `arr` to a multiple of 4.

```
void static_non_align(void){
    char arr[12], *ptr;
    int *dest;

    ptr = &arr[0];
    dest = (int*)ptr;
}
```

Example - Allocation with a Function

```
#include <stdlib.h>

void *my_alloc(int size) {
    void *ptr_func = malloc(size);
    if(ptr_func == NULL) exit(-1);
    return ptr_func;
}

void fun_non_align(void){
    int *dest1;
    char *dest2;

    dest1 = (int*)my_alloc(13);  //defect
    dest2 = (char*)my_alloc(13); //not a defect
}
```

In this example, the software raises a defect on the conversion of the pointer returned by `my_alloc(13)` to an `int*` in line 11. `my_alloc(13)` returns a pointer with a dynamically allocated size of 13 bytes. The size of `dest1` is 4 bytes, which is not a divisor of 13. This misalignment causes the **Wrong allocated object size for cast** defect. In line 12, the same function call, `my_alloc(13)`, does not call a defect for the conversion to `dest2` because the size of `char*`, 1 byte, a divisor of 13.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the argument for `my_alloc` to a multiple of 4.

```
#include <stdlib.h>

void *my_alloc(int size) {
    void *ptr_func = malloc(size);
    if(ptr_func == NULL) exit(-1);
    return ptr_func;
}

void fun_non_align(void){
    int *dest1;
    char *dest2;

    dest1 = (int*)my_alloc(12);
    dest2 = (char*)my_alloc(13);
}
```

Check Information

Group: Rec. 08. Memory Management (MEM)

See Also

External Websites

MEM02-C

Introduced in R2019a

CERT C: Rec. MEM03-C

Clear sensitive information stored in reusable resources

Description

Rule Definition

Clear sensitive information stored in reusable resources.

Examples

Sensitive heap memory not cleared before release

Description

Sensitive heap memory not cleared before release detects dynamically allocated memory containing sensitive data. If you do not clear the sensitive data when you free the memory, Bug Finder raises a defect on the `free` function.

Risk

If the memory zone is reallocated, an attacker can still inspect the sensitive data in the old memory zone.

Fix

Before calling `free`, clear out the sensitive data using `memset` or `SecureZeroMemory`.

Example - Sensitive Buffer Freed, Not Cleared

```
#include <unistd.h>
#include <stdlib.h>
#include <string.h>
#include <sys/types.h>
#include <pwd.h>
```

```
void sensitiveheapnotcleared(const char * my_user) {
    struct passwd* result, pwd;
    long bufsize = sysconf(_SC_GETPW_R_SIZE_MAX);
    char* buf = (char*) malloc(1024);
    getpwnam_r(my_user, &pwd, buf, bufsize, &result);
    free(buf);
}
```

In this example, the function uses a buffer of passwords and frees the memory before the end of the function. However, the data in the memory is not cleared by using the `free` command.

Correction — Nullify Data

One possible correction is to write over the data to clear out the sensitive information. This example uses `memset` to write over the data with zeros.

```
#include <unistd.h>
#include <stdlib.h>
#include <string.h>
#include <sys/types.h>
#include <pwd.h>
#include <assert.h>

#define isNull(arr) for(int i=0;i<(sizeof(arr)/sizeof(arr[0]));i++) assert(arr[i]==0)

void sensitiveheapnotcleared(const char * my_user) {
    struct passwd* result, pwd;
    long bufsize = sysconf(_SC_GETPW_R_SIZE_MAX);
    char* buf = (char*) malloc(1024);

    if (buf) {
        getpwnam_r(my_user, &pwd, buf, bufsize, &result);
        memset(buf, 0, (size_t)1024);
        isNull(buf);
        free(buf);
    }
}
```

Uncleared sensitive data in stack

Description

Uncleared sensitive data in stack detects static memory containing sensitive data. If you do not clear the sensitive data from your stack before exiting the function or program, Bug Finder raises a defect on the last curly brace.

Risk

Leaving sensitive information in your stack, such as passwords or user information, allows an attacker additional access to the information after your program has ended.

Fix

Before exiting a function or program, clear out the memory zones that contain sensitive data by using `memset` or `SecureZeroMemory`.

Example - Static Buffer of Password Information

```
#include <unistd.h>
#include <sys/types.h>
#include <pwd.h>

void bug_sensitivestacknotcleared(const char * my_user) {
    struct passwd* result, pwd;
    long bufsize = sysconf(_SC_GETPW_R_SIZE_MAX);
    char buf[1024] = "";
    getpwnam_r(my_user, &pwd, buf, bufsize, &result);
}
```

In this example, a static buffer is filled with password information. The program frees the stack memory at the end of the program. However, the data is still accessible from the memory.

Correction — Clear Memory

One possible correction is to write over the memory before exiting the function. This example uses `memset` to clear the data from the buffer memory.

```
#include <unistd.h>
#include <string.h>
#include <sys/types.h>
```

```
#include <pwd.h>
#include <assert.h>

#define isNull(arr) for(int i=0; i<(sizeof(arr)/sizeof(arr[0])); i++) assert(arr[i]==0)

void corrected_sensitivestacknotcleared(const char * my_user) {
    struct passwd* result, pwd;
    long bufsize = sysconf(_SC_GETPW_R_SIZE_MAX);
    char buf[1024] = "";
    getpwnam_r(my_user, &pwd, buf, bufsize, &result);
    memset(buf, 0, (size_t)1024);
    isNull(buf);
}
```

Check Information

Group: Rec. 08. Memory Management (MEM)

See Also

External Websites

MEM03-C

Introduced in R2019a

CERT C: Rec. MEM04-C

Beware of zero-length allocations

Description

Rule Definition

Beware of zero-length allocations.

Examples

Variable length array with nonpositive size

Description

Variable length array with non-positive size occurs when size of a variable-length array is zero or negative.

Risk

If the size of a variable-length array is zero or negative, unexpected behavior can occur, such as stack overflow.

Fix

When you declare a variable-length array as a local variable in a function:

- If you use a function parameter as the array size, check that the parameter is positive.
- If you use the result of a computation on a function parameter as the array size, check that the result is positive.

You can place a test for positive value either before the function call or the array declaration in the function body.

Example - Nonpositive Array Size

```
int input(void);

void add_scalar(int n, int m) {
    int r=0;
    int arr[m][n];
    for (int i=0; i<m; i++) {
        for (int j=0; j<n; j++) {
            arr[i][j] = input();
            r += arr[i][j];
        }
    }
}

void main() {
    add_scalar(2,2);
    add_scalar(-1,2);
    add_scalar(2,0);
}
```

In this example, the second and third calls to `add_scalar` result in a negative and zero size of `arr`.

Correction — Make Array Size Positive

One possible correction is fix or remove calls that result in a nonpositive array size.

Tainted sign change conversion

Description

Tainted sign change conversion looks for values from unsecure sources that are converted, implicitly or explicitly, from signed to unsigned values.

For example, functions that use `size_t` as arguments implicitly convert the argument to an unsigned integer. Some functions that implicitly convert `size_t` are:

```
bcmp
memcpy
memmove
strncmp
strncpy
```

```
calloc
malloc
memalign
```

Risk

If you convert a small negative number to unsigned, the result is a large positive number. The large positive number can create security vulnerabilities. For example, if you use the unsigned value in:

- Memory size routines — causes allocating memory issues.
- String manipulation routines — causes buffer overflow.
- Loop boundaries — causes infinite loops.

Fix

To avoid converting unsigned negative values, check that the value being converted is within an acceptable range. For example, if the value represents a size, validate that the value is not negative and less than the maximum value size.

Example - Set Memory Value with Size Argument

```
#include <stdlib.h>
#include <string.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

void bug_taintedsignchange(int size) {
    char str[SIZE128] = "";
    if (size<SIZE128) {
        memset(str, 'c', size);
    }
}
```

In this example, a `char` buffer is created and filled using `memset`. The size argument to `memset` is an input argument to the function.

The call to `memset` implicitly converts `size` to unsigned integer. If `size` is a large negative number, the absolute value could be too large to represent as an integer, causing a buffer overflow.

Correction — Check Value of `size`

One possible correction is to check if `size` is inside the valid range. This correction checks if `size` is greater than zero and less than the buffer size before calling `memset`.

```
#include <stdlib.h>
#include <string.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

void corrected_taintedsignchange(int size) {
    char str[SIZE128] = "";
    if (size>0 && size<SIZE128) {
        memset(str, 'c', size);
    }
}
```

Tainted size of variable length array

Description

Tainted size of variable length array detects variable length arrays (VLA) whose size is from an unsecure source.

Risk

If an attacker changed the size of your VLA to an unexpected value, it can cause your program to crash or behave unexpectedly.

If the size is non-positive, the behavior of the VLA is undefined. Your program does not perform as expected.

If the size is unbounded, the VLA can cause memory exhaustion or stack overflow.

Fix

Validate your VLA size to make sure that it is positive and less than a maximum value.

Example - Input Argument Used as Size of VLA

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int taintedvlasize(int size) {

    int tabvla[size];
    int res = 0;
    for (int i=0 ; i<SIZE10 ; ++i) {
        tabvla[i] = i*i;
        res += tabvla[i];
    }
    return res;
}
```

In this example, a variable length array size is based on an input argument. Because this input argument value is not checked, the size may be negative or too large.

Correction — Check VLA Size

One possible correction is to check the size variable before creating the variable length array. This example checks if the size is larger than 10 and less than 100, before creating the VLA

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int taintedvlasize(int size) {
    int res = 0;
    if (size>SIZE10 && size<SIZE100) {
        int tabvla[size];
        for (int i=0 ; i<SIZE10 ; ++i) {
            tabvla[i] = i*i;
            res += tabvla[i];
        }
    }
    return res;
}
```

Check Information

Group: Rec. 08. Memory Management (MEM)

See Also

External Websites

MEM04-C

Introduced in R2019a

CERT C: Rec. MEM05-C

Avoid large stack allocations

Description

Rule Definition

Avoid large stack allocations.

Examples

Direct or indirect function call to itself

Description

The issue occurs when your code contains functions that call themselves directly or indirectly.

Risk

Variables local to a function are stored in the call stack. If a function calls itself directly or indirectly several times, the available stack space can be exceeded, causing serious failure. Unless the recursion is tightly controlled, it is difficult to determine the maximum stack space required.

Example - Direct and Indirect Recursion

```
void foo1( void ) {     /* Non-compliant - Indirect recursion foo1->foo2->foo1... */
    foo2();
    foo1();               /* Non-compliant - Direct recursion */
}

void foo2( void ) {
    foo1();
}
```

In this example, the rule is violated because of:

- Direct recursion `foo1` → `foo1`.
- Indirect recursion `foo1` → `foo2` → `foo1`.

Variable length array with nonpositive size

Description

Variable length array with non-positive size occurs when size of a variable-length array is zero or negative.

Risk

If the size of a variable-length array is zero or negative, unexpected behavior can occur, such as stack overflow.

Fix

When you declare a variable-length array as a local variable in a function:

- If you use a function parameter as the array size, check that the parameter is positive.
- If you use the result of a computation on a function parameter as the array size, check that the result is positive.

You can place a test for positive value either before the function call or the array declaration in the function body.

Example - Nonpositive Array Size

```
int input(void);

void add_scalar(int n, int m) {
    int r=0;
    int arr[m][n];
    for (int i=0; i<m; i++) {
        for (int j=0; j<n; j++) {
            arr[i][j] = input();
            r += arr[i][j];
        }
    }
}
```

```
void main() {
    add_scalar(2,2);
    add_scalar(-1,2);
    add_scalar(2,0);
}
```

In this example, the second and third calls to `add_scalar` result in a negative and zero size of `arr`.

Correction — Make Array Size Positive

One possible correction is fix or remove calls that result in a nonpositive array size.

Tainted size of variable length array

Description

Tainted size of variable length array detects variable length arrays (VLA) whose size is from an unsecure source.

Risk

If an attacker changed the size of your VLA to an unexpected value, it can cause your program to crash or behave unexpectedly.

If the size is non-positive, the behavior of the VLA is undefined. Your program does not perform as expected.

If the size is unbounded, the VLA can cause memory exhaustion or stack overflow.

Fix

Validate your VLA size to make sure that it is positive and less than a maximum value.

Example - Input Argument Used as Size of VLA

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};
```

```
int taintedvlasize(int size) {

    int tabvla[size];
    int res = 0;
    for (int i=0 ; i<SIZE10 ; ++i) {
        tabvla[i] = i*i;
        res += tabvla[i];
    }
    return res;
}
```

In this example, a variable length array size is based on an input argument. Because this input argument value is not checked, the size may be negative or too large.

Correction — Check VLA Size

One possible correction is to check the size variable before creating the variable length array. This example checks if the size is larger than 10 and less than 100, before creating the VLA

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int taintedvlasize(int size) {
    int res = 0;
    if (size>SIZE10 && size<SIZE100) {
        int tabvla[size];
        for (int i=0 ; i<SIZE10 ; ++i) {
            tabvla[i] = i*i;
            res += tabvla[i];
        }
    }
    return res;
}
```

Check Information

Group: Rec. 08. Memory Management (MEM)

See Also

External Websites

MEM05-C

Introduced in R2019a

CERT C: Rec. MEM06-C

Ensure that sensitive data is not written out to disk

Description

Rule Definition

Ensure that sensitive data is not written out to disk.

Examples

Sensitive data printed out

Description

Sensitive data printed out detects print functions, such as `stdout` or `stderr`, that print sensitive information.

The checker considers the following as sensitive information:

- Return values of password manipulation functions such as `getpw`, `getpwnam` or `getpwuid`.
- Input values of functions such as the Windows-specific function `LogonUser`.

Risk

Printing sensitive information, such as passwords or user information, allows an attacker additional access to the information.

Fix

One fix for this defect is to not print out sensitive information.

If you are saving your logfile to an external file, set the file permissions so that attackers cannot access the logfile information.

Example - Printing Passwords

```
#include <sys/types.h>
#include <pwd.h>
#include <stdio.h>
#include <string.h>
#include <unistd.h>

extern void verify_null(const char* buf);
void bug_sensitivedataprint(const char * my_user) {
    struct passwd* result, pwd;
    long bufsize = sysconf(_SC_GETPW_R_SIZE_MAX);
    char buf[1024] = "";
    getpwnam_r(my_user, &pwd, buf, bufsize, &result);
    puts("Name\n");
    puts(pwd.pw_name);
    puts("PassWord\n");
    puts(pwd.pw_passwd);
    memset(buf, 0, sizeof(buf));
    verify_null(buf);
}
```

In this example, Bug Finder flags `puts` for printing out the password `pwd.pw_passwd`.

Correction — Obfuscate the Password

One possible correction is to obfuscate the password information so that the information is not visible.

```
#include <sys/types.h>
#include <pwd.h>
#include <stdio.h>
#include <string.h>
#include <unistd.h>

extern void verify_null(const char* buf);

void sensitivedataprint(const char * my_user) {
    struct passwd* result, pwd;
    long bufsize = sysconf(_SC_GETPW_R_SIZE_MAX);
    char buf[1024] = "";
    getpwnam_r(my_user, &pwd, buf, bufsize, &result);
    puts("Name\n");
    puts(pwd.pw_name);
    puts("PassWord\n");
```

```
    puts("XXXXXXXX\n");
    memset(buf, 0, sizeof(buf));
    verify_null(buf);
}
```

Check Information

Group: Rec. 08. Memory Management (MEM)

See Also

External Websites

MEM06-C

Introduced in R2019a

CERT C: Rec. MEM11-C

Do not assume infinite heap space

Description

Rule Definition

Do not assume infinite heap space.

Examples

Unprotected dynamic memory allocation

Description

Unprotected dynamic memory allocation occurs when you do not check after dynamic memory allocation whether the memory allocation succeeded.

Risk

When memory is dynamically allocated using `malloc`, `calloc`, or `realloc`, it returns a value `NULL` if the requested memory is not available. If the code following the allocation accesses the memory block without checking for this `NULL` value, this access is not protected from failures.

Fix

Check the return value of `malloc`, `calloc`, or `realloc` for NULL before accessing the allocated memory location.

```
int *ptr = malloc(size * sizeof(int));

if(ptr) /* Check for NULL */
{
   /* Memory access through ptr */
}
```

Example - Unprotected dynamic memory allocation error

```
#include <stdlib.h>

void Assign_Value(void)
{
  int* p = (int*)calloc(5, sizeof(int));

  *p = 2;
  /* Defect: p is not checked for NULL value */

  free(p);
}
```

If the memory allocation fails, the function `calloc` returns `NULL` to `p`. Before accessing the memory through `p`, the code does not check whether `p` is `NULL`

Correction — Check for NULL Value

One possible correction is to check whether `p` has value `NULL` before dereference.

```
#include <stdlib.h>

void Assign_Value(void)
 {
   int* p = (int*)calloc(5, sizeof(int));

   /* Fix: Check if p is NULL */
   if(p!=NULL) *p = 2;

   free(p);
 }
```

Check Information

Group: Rec. 08. Memory Management (MEM)

See Also

External Websites

MEM11-C

Introduced in R2019a

CERT C: Rec. MEM12-C

Consider using a goto chain when leaving a function on error when using and releasing resources

Description

Rule Definition

Consider using a goto chain when leaving a function on error when using and releasing resources.

Examples

Memory leak

Description

Memory leak occurs when you do not free a block of memory allocated through `malloc`, `calloc`, `realloc`, or `new`. If the memory is allocated in a function, the defect does not occur if:

- Within the function, you free the memory using `free` or `delete`.
- The function returns the pointer assigned by `malloc`, `calloc`, `realloc`, or `new`.
- The function stores the pointer in a global variable or in a parameter.

Risk

Dynamic memory allocation functions such as `malloc` allocate memory on the heap. If you do not release the memory after use, you reduce the amount of memory available for another allocation. On embedded systems with limited memory, you might end up exhausting available heap memory even during program execution.

Fix

Determine the scope where the dynamically allocated memory is accessed. Free the memory block at the end of this scope.

To free a block of memory, use the `free` function on the pointer that was used during memory allocation. For instance:

```
ptr = (int*)malloc(sizeof(int));
...
free(ptr);
```

It is a good practice to allocate and free memory in the same module at the same level of abstraction. For instance, in this example, `func` allocates and frees memory at the same level but `func2` does not.

```
void func() {
  ptr = (int*)malloc(sizeof(int));
  {
    ...
  }
  free(ptr);
}

void func2() {
  {
   ptr = (int*)malloc(sizeof(int));
   ...
  }
  free(ptr);
}
```

See CERT-C Rule MEM00-C.

Example - Dynamic Memory Not Released Before End of Function

```
#include<stdlib.h>
#include<stdio.h>

void assign_memory(void)
{
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL)
        {
         printf("Memory allocation failed");
```

```
         return;
        }


    *pi = 42;
    /* Defect: pi is not freed */
}
```

In this example, `pi` is dynamically allocated by `malloc`. The function `assign_memory` does not free the memory, nor does it return `pi`.

Correction — Free Memory

One possible correction is to free the memory referenced by `pi` using the `free` function. The `free` function must be called before the function `assign_memory` terminates

```
#include<stdlib.h>
#include<stdio.h>

void assign_memory(void)
{
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL)
        {
         printf("Memory allocation failed");
         return;
        }
    *pi = 42;

    /* Fix: Free the pointer pi*/
    free(pi);
}
```

Correction — Return Pointer from Dynamic Allocation

Another possible correction is to return the pointer `pi`. Returning `pi` allows the function calling `assign_memory` to free the memory block using `pi`.

```
#include<stdlib.h>
#include<stdio.h>

int* assign_memory(void)
{
    int* pi = (int*)malloc(sizeof(int));
```

```
    if (pi == NULL)
        {
            printf("Memory allocation failed");
            return(pi);
        }
    *pi = 42;

    /* Fix: Return the pointer pi*/
    return(pi);
}
```

Example - Memory Leak with New/Delete

```
#define NULL '\0'

void initialize_arr1(void)
{
    int *p_scalar = new int(5);
}

void initialize_arr2(void)
{
    int *p_array = new int[5];
}
```

In this example, the functions create two variables, `p_scalar` and `p_array`, using the `new` keyword. However, the functions end without cleaning up the memory for these pointers. Because the functions used `new` to create these variables, you must clean up their memory by calling `delete` at the end of each function.

Correction — Add Delete

To correct this error, add a `delete` statement for every `new` initialization. If you used brackets `[]` to instantiate a variable, you must call delete with brackets as well.

```
#define NULL '\0'

void initialize_arrs(void)
{
    int *p_scalar = new int(5);
    int *p_array = new int[5];
```

```
    delete p_scalar;
    p_scalar = NULL;

    delete[] p_array;
    p_scalar = NULL;
}
```

Resource leak

Description

Resource leak occurs when you open a file stream by using a `FILE` pointer but do not close it before:

- The end of the pointer's scope.
- Assigning the pointer to another stream.

Risk

If you do not release file handles explicitly as soon as possible, a failure can occur due to exhaustion of resources.

Fix

Close a `FILE` pointer before the end of its scope, or before you assign the pointer to another stream.

Example - `FILE` Pointer Not Released Before End of Scope

```
#include <stdio.h>

void func1( void ) {
    FILE *fp1;
    fp1 = fopen ( "data1.txt", "w" );
    fprintf ( fp1, "*" );

    fp1 = fopen ( "data2.txt", "w" );
    fprintf ( fp1, "!" );
    fclose ( fp1 );
}
```

In this example, the file pointer `fp1` is pointing to a file `data1.txt`. Before `fp1` is explicitly dissociated from the file stream of `data1.txt`, it is used to access another file `data2.txt`.

Correction — Release `FILE` Pointer

One possible correction is to explicitly dissociate `fp1` from the file stream of `data1.txt`.

```
#include <stdio.h>

void func1( void ) {
    FILE *fp1;
    fp1 = fopen ( "data1.txt", "w" );
    fprintf ( fp1, "*" );
    fclose(fp1);

    fp1 = fopen ( "data2.txt", "w" );
    fprintf ( fp1, "!" );
    fclose ( fp1 );
}
```

Check Information

Group: Rec. 08. Memory Management (MEM)

See Also

External Websites

MEM12-C

Introduced in R2019a

Rec. 09. Input Output (FIO)

CERT C: Rec. FIO02-C

Canonicalize path names originating from tainted sources

Description

Rule Definition

Canonicalize path names originating from tainted sources.

Examples

Vulnerable path manipulation

Description

Vulnerable path manipulation detects relative or absolute path traversals. If the path traversal contains a tainted source, or you use the path to open/create files, Bug Finder raises a defect.

Risk

Relative path elements, such as `".."` can resolve to locations outside the intended folder. Absolute path elements, such as `"/abs/path"` can also resolve to locations outside the intended folder.

An attacker can use these types of path traversal elements to traverse to the rest of the file system and access other files or folders.

Fix

Avoid vulnerable path traversal elements such as `/../` and `/abs/path/`. Use fixed file names and locations wherever possible.

Example - Relative Path Traversal

```
# include <stdio.h>
# include <string.h>
```

```
# include <wchar.h>
# include <sys/types.h>
# include <sys/stat.h>
# include <fcntl.h>
# include <unistd.h>
# include <stdlib.h>
# define BASEPATH "/tmp/"
# define FILENAME_MAX 512

static void Relative_Path_Traversal(void)
{
    char * data;
    char data_buf[FILENAME_MAX] = BASEPATH;
    char sub_buf[FILENAME_MAX];

    if (fgets(sub_buf, FILENAME_MAX, stdin) == NULL) exit (1);
    data = data_buf;
    strcat(data, sub_buf);

    FILE *file = NULL;
    file = fopen(data, "wb+");
    if (file != NULL) fclose(file);
}

int path_call(void){
    Relative_Path_Traversal();
}
```

This example opens a file from `"/tmp/"`, but uses a relative path to the file. An external user can manipulate this relative path when `fopen` opens the file.

Correction — Use Fixed File Name

One possible correction is to use a fixed file name instead of a relative path. This example uses `file.txt`.

```
# include <stdio.h>
# include <string.h>
# include <wchar.h>
# include <sys/types.h>
# include <sys/stat.h>
# include <fcntl.h>
# include <unistd.h>
# include <stdlib.h>
# define BASEPATH "/tmp/"
```

```
# define FILENAME_MAX 512

static void Relative_Path_Traversal(void)
{
    char * data;
    char data_buf[FILENAME_MAX] = BASEPATH;
    data = data_buf;

    /* FIX: Use a fixed file name */
    strcat(data, "file.txt");
    FILE *file = NULL;
    file = fopen(data, "wb+");
    if (file != NULL) fclose(file);
}

int path_call(void){
    Relative_Path_Traversal();
}
```

Check Information

Group: Rec. 09. Input Output (FIO)

See Also

External Websites

FIO02-C

Introduced in R2019a

CERT C: Rec. FIO11-C

Take care when specifying the mode parameter of fopen()

Description

Rule Definition

Take care when specifying the mode parameter of fopen().

Examples

Bad file access mode or status

Description

Bad file access mode or status occurs when you use functions in the `fopen` or `open` group with invalid or incompatible file access modes, file creation flags, or file status flags as arguments. For instance, for the `open` function, examples of valid:

- Access modes include `O_RDONLY`, `O_WRONLY`, and `O_RDWR`
- File creation flags include `O_CREAT`, `O_EXCL`, `O_NOCTTY`, and `O_TRUNC`.
- File status flags include `O_APPEND`, `O_ASYNC`, `O_CLOEXEC`, `O_DIRECT`, `O_DIRECTORY`, `O_LARGEFILE`, `O_NOATIME`, `O_NOFOLLOW`, `O_NONBLOCK`, `O_NDELAY`, `O_SHLOCK`, `O_EXLOCK`, `O_FSYNC`, `O_SYNC` and so on.

The defect can occur in the following situations.

Situation	Risk	Fix
You pass an empty or invalid access mode to the `fopen` function. According to the ANSI C standard, the valid access modes for `fopen` are: • `r`,`r+` • `w`,`w+` • `a`,`a+` • `rb`, `wb`, `ab` • `r+b`, `w+b`, `a+b` • `rb+`, `wb+`, `ab+`	`fopen` has undefined behavior for invalid access modes. Some implementations allow extension of the access mode such as: • GNU: `rb +cmxe,ccs=utf` • Visual C++: `a+t`, where `t` specifies a text mode. However, your access mode string must begin with one of the valid sequences.	Pass a valid access mode to `fopen`.
You pass the status flag `O_APPEND` to the `open` function without combining it with either `O_WRONLY` or `O_RDWR`.	`O_APPEND` indicates that you intend to add new content at the end of a file. However, without `O_WRONLY` or `O_RDWR`, you cannot write to the file. The `open` function does not return -1 for this logical error.	Pass either `O_APPEND|O_WRONLY` or `O_APPEND|O_RDWR` as access mode.
You pass the status flags `O_APPEND` and `O_TRUNC` together to the `open` function.	`O_APPEND` indicates that you intend to add new content at the end of a file. However, `O_TRUNC` indicates that you intend to truncate the file to zero. Therefore, the two modes cannot operate together. The `open` function does not return -1 for this logical error.	Depending on what you intend to do, pass one of the two modes.

Situation	Risk	Fix
You pass the status flag `O_ASYNC` to the `open` function.	On certain implementations, the mode `O_ASYNC` does not enable signal-driven I/O operations.	Use the `fcntl(pathname, F_SETFL, O_ASYNC);` instead.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Invalid Access Mode with `fopen`

```
#include <stdio.h>

void func(void) {
    FILE *file = fopen("data.txt", "rw");
    if(file!=NULL) {
        fputs("new data",file);
        fclose(file);
    }
}
```

In this example, the access mode `rw` is invalid. Because `r` indicates that you open the file for reading and `w` indicates that you create a new file for writing, the two access modes are incompatible.

Correction — Use Either `r` or `w` as Access Mode

One possible correction is to use the access mode corresponding to what you intend to do.

```
#include <stdio.h>

void func(void) {
    FILE *file = fopen("data.txt", "w");
    if(file!=NULL) {
```

```
        fputs("new data",file);
        fclose(file);
    }
}
```

Check Information

Group: Rec. 09. Input Output (FIO)

See Also

External Websites

FIO11-C

Introduced in R2019a

CERT C: Rec. FIO21-C

Do not create temporary files in shared directories

Description

Rule Definition

Do not create temporary files in shared directories.

Examples

Use of non-secure temporary file

Description

Use of non-secure temporary file looks for temporary file routines that are not secure.

Risk

If an attacker guesses the file name generated by a standard temporary file routine, the attacker can:

- Cause a race condition when you generate the file name.
- Precreate a file of the same name, filled with malicious content. If your program reads the file, the attacker's file can inject the malicious code.
- Create a symbolic link to a file storing sensitive data. When your program writes to the temporary file, the sensitive data is deleted.

Fix

To create temporary files, use a more secure standard temporary file routine, such as `mkstemp` from POSIX.1-2001.

Also, when creating temporary files with routines that allow flags, such as `mkostemp`, use the exclusion flag `O_EXCL` to avoid race conditions.

Example - Temp File Created With `tempnam`

```
#define _BSD_SOURCE
#define _XOPEN_SOURCE
#define _GNU_SOURCE

#include <stdio.h>
#include <stdlib.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <fcntl.h>
#include <unistd.h>

int test_temp()
{
    char tpl[] = "abcXXXXXX";
    char suff_tpl[] = "abcXXXXXXsuff";
    char *filename = NULL;
    int fd;

    filename = tempnam("/var/tmp", "foo_");

    if (filename != NULL)
    {
        printf("generated tmp name (%s) in (%s:%s:%s)\n",
               filename, getenv("TMPDIR") ? getenv("TMPDIR") : "$TMPDIR",
               "/var/tmp", P_tmpdir);

        fd = open(filename, O_CREAT, S_IRWXU|S_IRUSR);
        if (fd != -1)
        {
            close(fd);
            unlink(filename);
            return 1;
        }
    }
    return 0;
}
```

In this example, Bug Finder flags `open` because it tries to use an unsecure temporary file. The file is opened without exclusive privileges. An attacker can access the file causing various risks on page 1-544.

Correction — Add O_EXCL Flag

One possible correction is to add the O_EXCL flag when you open the temporary file.

```
#define _BSD_SOURCE
#define _XOPEN_SOURCE
#define _GNU_SOURCE

#include <stdio.h>
#include <stdlib.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <fcntl.h>
#include <unistd.h>

int test_temp()
{
    char tpl[] = "abcXXXXXX";
    char suff_tpl[] = "abcXXXXXXsuff";
    char *filename = NULL;
    int fd;

    filename = tempnam("/var/tmp", "foo_");

    if (filename != NULL)
    {
        printf("generated tmp name (%s) in (%s:%s:%s)\n",
               filename, getenv("TMPDIR") ? getenv("TMPDIR") : "$TMPDIR",
               "/var/tmp", P_tmpdir);

        fd = open(filename, O_CREAT|O_EXCL, S_IRWXU|S_IRUSR);
        if (fd != -1)
        {
            close(fd);
            unlink(filename);
            return 1;
        }
    }
    return 0;
}
```

Check Information

Group: Rec. 09. Input Output (FIO)

See Also

External Websites

FIO21-C

Introduced in R2019a

CERT C: Rec. FIO24-C

Do not open a file that is already open

Description

Rule Definition

Do not open a file that is already open.

Examples

Opening previously opened resource

Description

Opening previously opened resource checks for file opening functions that are opening an already opened file.

Risk

If you open a resource multiple times, you can encounter:

- A race condition when accessing the file.
- Undefined or unexpected behavior for that file.
- Portability issues when you run your program on different targets.

Fix

Once a resource is open, close the resource before reopening.

Example - File Reopened With New Permissions

```
#include <stdio.h>
const char* logfile = "my_file.log";
```

```
void doubleresourceopen()
{
    FILE* fpa = fopen(logfile, "w");
    if (fpa == NULL) {
        return;
    }
    (void)fprintf(fpa, "Writing");
    FILE* fpb = fopen(logfile, "r");
    (void)fclose(fpa);
    (void)fclose(fpb);
}
```

In this example, a `logfile` is opened in the first line of this function with write privileges. Halfway through the function, the `logfile` is opened again with read privileges.

Correction — Close Before Reopening

One possible correction is to close the file before reopening the file with different privileges.

```
#include <stdio.h>
const char* logfile = "my_file.log";

void doubleresourceopen()
{
    FILE* fpa = fopen(logfile, "w");
    if (fpa == NULL) {
        return;
    }
    (void)fprintf(fpa, "Writing");
    (void)fclose(fpa);
    FILE* fpb = fopen(logfile, "r");
    (void)fclose(fpb);
}
```

Check Information

Group: Rec. 09. Input Output (FIO)

See Also

External Websites

FIO24-C

Introduced in R2019a

Rec. 10. Environment (ENV)

CERT C: Rec. ENV01-C

Do not make assumptions about the size of an environment variable

Description

Rule Definition

Do not make assumptions about the size of an environment variable.

Examples

Tainted NULL or non-null-terminated string

Description

Tainted NULL or non-null-terminated string looks for strings from unsecure sources that are being used in string manipulation routines that implicitly dereference the string buffer. For example, `strcpy` or `sprintf`.

Tainted NULL or non-null-terminated string raises no defect for a string returned from a call to `scanf`-family variadic functions. Similarly, no defect is raised when you pass the string with a `%s` specifier to `printf`-family variadic functions.

Note If you reference a string using the form `ptr[i]`, `*ptr`, or pointer arithmetic, Bug Finder raises a **Use of tainted pointer** defect instead. The **Tainted NULL or non-null-terminated string** defect is raised only when the pointer is used as a string.

Risk

If a string is from an unsecure source, it is possible that an attacker manipulated the string or pointed the string pointer to a different memory location.

If the string is NULL, the string routine cannot dereference the string, causing the program to crash. If the string is not null-terminated, the string routine might not know

when the string ends. This error can cause you to write out of bounds, causing a buffer overflow.

Fix

Validate the string before you use it. Check that:

- The string is not NULL.
- The string is null-terminated
- The size of the string matches the expected size.

Example - Getting String from Input Argument

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128

extern void print_str(const char*);

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}
```

In this example, the string `str` is concatenated with the argument `userstr`. The value of `userstr` is unknown. If the size of `userstr` is greater than the space available, the concatenation overflows.

Correction — Validate the Data

One possible correction is to check the size of `userstr` and make sure that the string is null-terminated before using it in `strncat`. This example uses a helper function, `sansitize_str`, to validate the string. The defects are concentrated in this function.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128

extern void print_str(const char*);

int sanitize_str(char* s) {
  int res = 0;
  if (s && (strlen(s) > 0)) { // TAINTED_STRING only flagged here
    // - string is not null
    // - string has a positive and limited size
    // - TAINTED_STRING on strlen used as a firewall
    res = 1;
  }
  return res;
}

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    if (sanitize_str(userstr))
      strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  if (sanitize_str(userstr))
    strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}
```

Correction — Validate the Data

Another possible correction is to call function `errorMsg` and `warningMsg` with specific strings.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128
```

```
extern void print_str(const char*);

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}

int manageSensorValue(int sensorValue) {
  int ret = sensorValue;
  if ( sensorValue < 0 ) {
    errorMsg("sensor value should be positive");
    exit(1);
  } else if ( sensorValue > 50 ) {
    warningMsg("sensor value greater than 50 (applying threshold)...");
    sensorValue = 50;
  }

  return sensorValue;
}
```

Check Information

Group: Rec. 10. Environment (ENV)

See Also

External Websites

ENV01-C

Introduced in R2019a

Rec. 12. Error Handling (ERR)

CERT C: Rec. ERR00-C

Adopt and implement a consistent and comprehensive error-handling policy

Description

Rule Definition

Adopt and implement a consistent and comprehensive error-handling policy.

Examples

Error information not checked

Description

The issue occurs when you do not test the error information returned by a function.

The checking of this directive follows the same specifications as the defect checker `Returned value of a sensitive function not checked`.

This directive is only partially supported.

Risk

Typically a function indicates whether an error occurred during execution, via a special return value or by another means.

If a function provides a mechanism to determine errors, before you use the function return value, you must check for such errors.

Check Information

Group: Rec. 12. Error Handling (ERR)

See Also

External Websites

ERR00-C

Introduced in R2019a

Rec. 13. Application Programming Interfaces (API)

CERT C: Rec. API04-C

Provide a consistent and usable error-checking mechanism

Description

Rule Definition

Provide a consistent and usable error-checking mechanism.

Examples

Error information not checked

Description

The issue occurs when you do not test the error information returned by a function.

The checking of this directive follows the same specifications as the defect checker `Returned value of a sensitive function not checked`.

This directive is only partially supported.

Risk

Typically a function indicates whether an error occurred during execution, via a special return value or by another means.

If a function provides a mechanism to determine errors, before you use the function return value, you must check for such errors.

Check Information

Group: Rec. 13. Application Programming Interfaces (API)

See Also

External Websites

API04-C

Introduced in R2019a

Rec. 14. Concurrency (CON)

CERT C: Rec. CON01-C

Acquire and release synchronization primitives in the same module, at the same level of abstraction

Description

Rule Definition

Acquire and release synchronization primitives in the same module, at the same level of abstraction.

Examples

Missing lock

Description

Missing lock occurs when a task calls an unlock function before calling the corresponding lock function.

In multitasking code, a lock function begins a critical section of code and an unlock function ends it. When a task `my_task` calls a lock function `my_lock`, other tasks calling `my_lock` must wait till `my_task` calls the corresponding unlock function. Polyspace requires that both lock and unlock functions must have the form `void func(void)`.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**.

Risk

A call to an unlock function without a corresponding lock function can indicate a coding error. For instance, perhaps the unlock function does not correspond to the lock function that begins the critical section.

Fix

The fix depends on the root cause of the defect. For instance, if the defect occurs because of a mismatch between lock and unlock function, check the lock-unlock function pair in your Polyspace analysis configuration and fix the mismatch.

See examples of fixes below. To avoid the issue, you can follow the practice of calling the lock and unlock functions in the same module at the same level of abstraction. For instance, in this example, `func` calls the lock and unlock function at the same level but `func2` does not.

```
void func() {
  my_lock();
  {
    ...
  }
  my_unlock();
}

void func2() {
  {
   my_lock();
   ...
  }
  my_unlock();
}
```

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Missing lock

```
void begin_critical_section(void);
void end_critical_section(void);

int global_var;

void reset(void)
{
  begin_critical_section();
  global_var = 0;
```

```
  end_critical_section();
}

void my_task(void)
{
  global_var += 1;
  end_critical_section();
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	my_task, reset	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section	end_critical_section

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
   -entry-points my_task,reset
   -critical-section-begin begin_critical_section:cs1
   -critical-section-end end_critical_section:cs1
```

The example has two entry points, `my_task` and `reset`. `my_task` calls `end_critical_section` before calling `begin_critical_section`.

Correction — Provide Lock

One possible correction is to call the lock function `begin_critical_section` before the instructions in the critical section.

```
void begin_critical_section(void);
void end_critical_section(void);

int global_var;

void reset(void)
{
  begin_critical_section();
  global_var = 0;
  end_critical_section();
}

void my_task(void)
{
    begin_critical_section();
    global_var += 1;
    end_critical_section();
}
```

Example - Lock in Condition

```
void begin_critical_section(void);
void end_critical_section(void);

int global_var;

void reset() {
    begin_critical_section();
    global_var=0;
    end_critical_section();
}

void my_task(void) {
    int index=0;
    volatile int numCycles;

    while(numCycles) {
      if(index%10==0) {
        begin_critical_section();
        global_var ++;
      }
      end_critical_section();
```

```
      index++;
    }
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	my_task, reset	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section	end_critical_section

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
   -entry-points my_task,reset
   -critical-section-begin begin_critical_section:cs1
   -critical-section-end end_critical_section:cs1
```

The example has two entry points, `my_task` and `reset`.

In the `while` loop, `my_task` leaves a critical section through the call `end_critical_section();`. In an iteration of the `while` loop:

- If `my_task` enters the `if` condition branch, the critical section begins through a call to `begin_critical_section`.
- If `my_task` does not enter the `if` condition branch and leaves the `while` loop, the critical section does not begin. Therefore, a **Missing lock** defect occurs.
- If `my_task` does not enter the `if` condition branch and continues to the next iteration of the `while` loop, the unlock function `end_critical_section` is called again. A **Double unlock** defect occurs.

Because `numCycles` is a `volatile` variable, it can take any value. Any of the cases above are possible. Therefore, a **Missing lock** defect and a **Double unlock** defect appear on the call `end_critical_section`.

Missing unlock

Description

Missing unlock occurs when:

- A task calls a lock function.
- The task ends without a call to an unlock function.

In multitasking code, a lock function begins a critical section of code and an unlock function ends it. When a task, `my_task`, calls a lock function, `my_lock`, other tasks calling `my_lock` must wait until `my_task` calls the corresponding unlock function. Polyspace requires that both lock and unlock functions must have the form `void func(void)`.

To find this defect, before analysis, you must specify the multitasking options. On the **Configuration** pane, select **Multitasking**.

Risk

An unlock function ends a critical section so that other waiting tasks can enter the critical section. A missing unlock function can result in tasks blocked for an unnecessary length of time.

Fix

Identify the critical section of code, that is, the section that you want to be executed as an atomic block. At the end of this section, call the unlock function that corresponds to the lock function used at the beginning of the section.

There can be other reasons and corresponding fixes for the defect. Perhaps you called the incorrect unlock function. Check the lock-unlock function pair in your Polyspace analysis configuration and fix the mismatch.

See examples of fixes below. To avoid the issue, you can follow the practice of calling the lock and unlock functions in the same module at the same level of abstraction. For instance, in this example, `func` calls the lock and unlock function at the same level but `func2` does not.

```
void func() {
  my_lock();
  {
    ...
  }
  my_unlock();
}

void func2() {
  {
   my_lock();
   ...
  }
  my_unlock();
}
```

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Missing Unlock

```
void begin_critical_section(void);
void end_critical_section(void);

int global_var;

void reset()
{
    begin_critical_section();
    global_var = 0;
    end_critical_section();
}

void my_task(void)
{
    begin_critical_section();
    global_var += 1;
}
```

In this example, to emulate multitasking behavior, specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	my_task, reset	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section	end_critical_section

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
   -entry-points my_task,reset
   -critical-section-begin begin_critical_section:cs1
   -critical-section-end end_critical_section:cs1
```

The example has two entry points, `my_task` and `reset`. `my_task` enters a critical section through the call `begin_critical_section();`. `my_task` ends without calling `end_critical_section`.

Correction — Provide Unlock

One possible correction is to call the unlock function `end_critical_section` after the instructions in the critical section.

```
void begin_critical_section(void);
void end_critical_section(void);

int global_var;

void reset(void)
{
    begin_critical_section();
    global_var = 0;
    end_critical_section();
```

```
}

void my_task(void)
{
    begin_critical_section();
    global_var += 1;
    end_critical_section();
}
```

Example - Unlock in Condition

```
void begin_critical_section(void);
void end_critical_section(void);

int global_var;

void reset() {
    begin_critical_section();
    global_var=0;
    end_critical_section();
}

void my_task(void) {
    int index=0;
    volatile int numCycles;

    while(numCycles) {
      begin_critical_section();
      global_var ++;
      if(index%10==0) {
        global_var = 0;
        end_critical_section();
      }
      index++;
    }
}
```

In this example, to emulate multitasking behavior, specify the following options.

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	my_task, reset	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section	end_critical_section

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
   -entry-points my_task,reset
   -critical-section-begin begin_critical_section:cs1
   -critical-section-end end_critical_section:cs1
```

The example has two entry points, `my_task` and `reset`.

In the `while` loop, `my_task` enters a critical section through the call `begin_critical_section();`. In an iteration of the `while` loop:

- If `my_task` enters the `if` condition branch, the critical section ends through a call to `end_critical_section`.
- If `my_task` does not enter the `if` condition branch and leaves the `while` loop, the critical section does not end. Therefore, a **Missing unlock** defect occurs.
- If `my_task` does not enter the `if` condition branch and continues to the next iteration of the `while` loop, the lock function `begin_critical_section` is called again. A **Double lock** defect occurs.

Because `numCycles` is a `volatile` variable, it can take any value. Any of the cases above is possible. Therefore, a **Missing unlock** defect and a **Double lock** defect appear on the call `begin_critical_section`.

Correction — Place Unlock Outside Condition

One possible correction is to call the unlock function `end_critical_section` outside the `if` condition.

```
void begin_critical_section(void);
void end_critical_section(void);

int global_var;

void reset() {
    begin_critical_section();
    global_var=0;
    end_critical_section();
}

void my_task(void) {
    int index=0;
    volatile int numCycles;

    while(numCycles) {
      begin_critical_section();
      global_var ++;
      if(index%10==0) {
        global_var=0;
      }
      end_critical_section();
      index++;
    }
}
```

Correction — Place Unlock in Every Conditional Branch

Another possible correction is to call the unlock function `end_critical_section` in every branches of the `if` condition.

```
void begin_critical_section(void);
void end_critical_section(void);

int global_var;

void reset() {
    begin_critical_section();
    global_var=0;
```

```
    end_critical_section();
}

void my_task(void) {
    int index=0;
    volatile int numCycles;

    while(numCycles) {
      begin_critical_section();
      global_var ++;
      if(index%10==0) {
        global_var=0;
        end_critical_section();
      }
      else
        end_critical_section();
      index++;
    }
}
```

Double lock

Description

Double lock occurs when:

- A task calls a lock function `my_lock`.
- The task calls `my_lock` again before calling the corresponding unlock function.

In multitasking code, a lock function begins a critical section of code and an unlock function ends it. When a task `task1` calls a lock function `lock`, other tasks calling `lock` must wait until `task` calls the corresponding unlock function. Polyspace requires that both lock and unlock functions must have the form `void func(void)`.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**.

Risk

A call to a lock function begins a critical section so that other tasks have to wait to enter the same critical section. If the same lock function is called again within the critical section, the task blocks itself.

Fix

The fix depends on the root cause of the defect. A double lock defect often indicates a coding error. Perhaps you omitted the call to an unlock function to end a previous critical section and started the next critical section. Perhaps you wanted to use a different lock function for the second critical section.

Identify each critical section of code, that is, the section that you want to be executed as an atomic block. Call a lock function at the beginning of the section. Within the critical section, make sure that you do not call the lock function again. At the end of the section, call the unlock function that corresponds to the lock function.

See examples of fixes below. To avoid the issue, you can follow the practice of calling the lock and unlock functions in the same module at the same level of abstraction. For instance, in this example, `func` calls the lock and unlock function at the same level but `func2` does not.

```
void func() {
  my_lock();
  {
    ...
  }
  my_unlock();
}

void func2() {
  {
   my_lock();
   ...
  }
  my_unlock();
}
```

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Double Lock

```
int global_var;

void lock(void);
```

```
void unlock(void);

void task1(void)
{
    lock();
    global_var += 1;
    lock();
    global_var += 1;
    unlock();
}

void task2(void)
{
    lock();
    global_var += 1;
    unlock();
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	**Specification**	
`Configure multitasking manually`		
`Tasks (-entry-points)`	`my_task`, `reset`	
`Critical section details (-critical-section-begin -critical-section-end)`	**Starting routine**	**Ending routine**
	`lock`	`unlock`

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
   -entry-points task1,task2
   -critical-section-begin lock:cs1
   -critical-section-end unlock:cs1
```

`task1` enters a critical section through the call `lock();`. `task1` calls `lock` again before it leaves the critical section through the call `unlock();`.

Correction — Remove First Lock

If you want the first `global_var+=1;` to be outside the critical section, one possible correction is to remove the first call to `lock`. However, if other tasks are using `global_var`, this code can produce a `Data race` error.

```
int global_var;

void lock(void);
void unlock(void);

void task1(void)
{
    global_var += 1;
    lock();
    global_var += 1;
    unlock();
}

void task2(void)
{
    lock();
    global_var += 1;
    unlock();
}
```

Correction — Remove Second Lock

If you want the first `global_var+=1;` to be inside the critical section, one possible correction is to remove the second call to `lock`.

```
int global_var;

void lock(void);
void unlock(void);

void task1(void)
{
```

```
    lock();
    global_var += 1;
    global_var += 1;
    unlock();
}

void task2(void)
{
    lock();
    global_var += 1;
    unlock();
}
```

Correction — Add Another Unlock

If you want the second `global_var+=1;` to be inside a critical section, another possible correction is to add another call to `unlock`.

```
int global_var;

void lock(void);
void unlock(void);

void task1(void)
{
    lock();
    global_var += 1;
    unlock();
    lock();
    global_var += 1;
    unlock();
}

void task2(void)
{
    lock();
    global_var += 1;
    unlock();
}
```

Example - Double Lock with Function Call

```
int global_var;

void lock(void);
void unlock(void);

void performOperation(void) {
  lock();
  global_var++;
}

void task1(void)
{
    lock();
    global_var += 1;
    performOperation();
    unlock();
}

void task2(void)
{
    lock();
    global_var += 1;
    unlock();
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	my_task, reset	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	lock	unlock

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

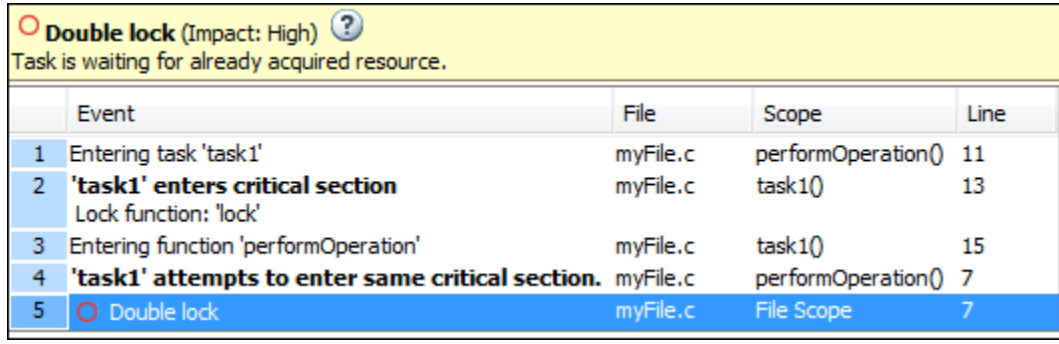
On the command-line, you can use the following:

```
polyspace-bug-finder
  -entry-points task1,task2
  -critical-section-begin lock:cs1
  -critical-section-end unlock:cs1
```

`task1` enters a critical section through the call `lock();`. `task1` calls the function `performOperation`. In `performOperation`, `lock` is called again even though `task1` has not left the critical section through the call `unlock();`.

In the result details for the defect, you see the sequence of instructions leading to the defect. For instance, you see that following the first entry into the critical section, the execution path:

- Enters function `performOperation`.
- Inside `performOperation`, attempts to enter the same critical section once again.



You can click each event to navigate to the corresponding line in the source code.

Correction — Remove Second Lock

One possible correction is to remove the call to `lock` in `task1`.

```
int global_var;
```

```
void lock(void);
void unlock(void);

void performOperation(void) {
  global_var++;
}

void task1(void)
{
    lock();
    global_var += 1;
    performOperation();
    unlock();
}

void task2(void)
{
    lock();
    global_var += 1;
    unlock();
}
```

Double unlock

Description

Double unlock occurs when:

- A task calls a lock function `my_lock`.
- The task calls the corresponding unlock function `my_unlock`.
- The task calls `my_unlock` again. The task does not call `my_lock` a second time between the two calls to `my_unlock`.

In multitasking code, a lock function begins a critical section of code and an unlock function ends it. When a task `task1` calls a lock function `my_lock`, other tasks calling `my_lock` must wait until `task1` calls the corresponding unlock function. Polyspace requires that both lock and unlock functions must have the form `void func(void)`.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**.

Risk

A double unlock defect can indicate a coding error. Perhaps you wanted to call a different unlock function to end a different critical section. Perhaps you called the unlock function prematurely the first time and only the second call indicates the end of the critical section.

Fix

The fix depends on the root cause of the defect.

Identify each critical section of code, that is, the section that you want to be executed as an atomic block. Call a lock function at the beginning of the section. Only at the end of the section, call the unlock function that corresponds to the lock function. Remove any other redundant call to the unlock function.

See examples of fixes below. To avoid the issue, you can follow the practice of calling the lock and unlock functions in the same module at the same level of abstraction. For instance, in this example, `func` calls the lock and unlock function at the same level but `func2` does not.

```
void func() {
  my_lock();
  {
    ...
  }
  my_unlock();
}

void func2() {
  {
   my_lock();
   ...
  }
  my_unlock();
}
```

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Double Unlock

```
int global_var;

void BEGIN_CRITICAL_SECTION(void);
void END_CRITICAL_SECTION(void);

void task1(void)
{
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    END_CRITICAL_SECTION();
    global_var += 1;
    END_CRITICAL_SECTION();
}

void task2(void)
{
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    END_CRITICAL_SECTION();
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	Value	
Configure multitasking manually	☑	
Tasks (-entry-points)	task1 task2	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	BEGIN_CRITICAL_SECTION	END_CRITICAL_SECTION

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
  -entry-points task1,task2
```

```
   -critical-section-begin BEGIN_CRITICAL_SECTION:cs1
   -critical-section-end END_CRITICAL_SECTION:cs1
```

`task1` enters a critical section through the call `BEGIN_CRITICAL_SECTION();`. `task1` leaves the critical section through the call `END_CRITICAL_SECTION();`. `task1` calls `END_CRITICAL_SECTION` again without an intermediate call to `BEGIN_CRITICAL_SECTION`.

Correction — Remove Second Unlock

If you want the second `global_var+=1;` to be outside the critical section, one possible correction is to remove the second call to `END_CRITICAL_SECTION`. However, if other tasks are using `global_var`, this code can produce a `Data race` error.

```
int global_var;

void BEGIN_CRITICAL_SECTION(void);
void END_CRITICAL_SECTION(void);

void task1(void)
{
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    END_CRITICAL_SECTION();
    global_var += 1;
}

void task2(void)
{
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    END_CRITICAL_SECTION();
}
```

Correction — Remove First Unlock

If you want the second `global_var+=1;` to be inside the critical section, one possible correction is to remove the first call to `END_CRITICAL_SECTION`.

```
int global_var;

void BEGIN_CRITICAL_SECTION(void);
void END_CRITICAL_SECTION(void);

void task1(void)
{
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    global_var += 1;
    END_CRITICAL_SECTION();
}

void task2(void)
{
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    END_CRITICAL_SECTION();
}
```

Correction — Add Another Lock

If you want the second `global_var+=1;` to be inside a critical section, another possible correction is to add another call to `BEGIN_CRITICAL_SECTION`.

```
int global_var;

void BEGIN_CRITICAL_SECTION(void);
void END_CRITICAL_SECTION(void);

void task1(void)
{
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    END_CRITICAL_SECTION();
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    END_CRITICAL_SECTION();
}

void task2(void)
```

```
{
    BEGIN_CRITICAL_SECTION();
    global_var += 1;
    END_CRITICAL_SECTION();
}
```

Check Information

Group: Rec. 14. Concurrency (CON)

See Also

External Websites

CON01-C

Introduced in R2019a

CERT C: Rec. CON05-C

Do not perform operations that can block while holding a lock

Description

Rule Definition

Do not perform operations that can block while holding a lock.

Examples

Blocking operation while holding lock

Description

Blocking operation while holding lock occurs when a task (thread) performs a potentially lengthy operation while holding a lock.

The checker considers calls to these functions as potentially lengthy:

- Functions that access a network such as `recv`
- System call functions such as `fork`, `pipe` and `system`
- Functions for I/O operations such as `getchar` and `scanf`
- File handling functions such as `fopen`, `remove` and `lstat`
- Directory manipulation functions such as `mkdir` and `rmdir`

The checker automatically detects certain primitives that hold and release a lock, for instance, `pthread_mutex_lock` and `pthread_mutex_unlock`. For the full list of primitives that are automatically detected, see the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

If a thread performs a lengthy operation when holding a lock, other threads that use the lock have to wait for the lock to be available. As a result, system performance can slow down or deadlocks can occur.

Fix

Perform the blocking operation before holding the lock or after releasing the lock.

Some functions detected by this checker can be called in a way that does not make them potentially lengthy. For instance, the function `recv` can be called with the parameter `O_NONBLOCK` which causes the call to fail if no message is available. When called with this parameter, `recv` does not wait for a message to become available.

Example - Network I/O Operations with `recv` While Holding Lock

```
#include <pthread.h>
#include <sys/socket.h>

pthread_mutexattr_t attr;
pthread_mutex_t mutex;

void thread_foo(void *ptr) {
  unsigned int num;
  int result;
  int sock;

  /* sock is a connected TCP socket */

  if ((result = pthread_mutex_lock(&mutex)) != 0) {
    /* Handle Error */
  }

  if ((result = recv(sock, (void *)&num, sizeof(unsigned int), 0)) < 0) {
    /* Handle Error */
  }

  /* ... */

  if ((result = pthread_mutex_unlock(&mutex)) != 0) {
    /* Handle Error */
  }
}
```

```
int main() {
  pthread_t thread;
  int result;

  if ((result = pthread_mutexattr_settype(
      &attr, PTHREAD_MUTEX_ERRORCHECK)) != 0) {
    /* Handle Error */
  }

  if ((result = pthread_mutex_init(&mutex, &attr)) != 0) {
    /* Handle Error */
  }

  if (pthread_create(&thread, NULL,(void*(*)(void*))& thread_foo, NULL) != 0) {
    /* Handle Error */
  }

  /* ... */

  pthread_join(thread, NULL);

  if ((result = pthread_mutex_destroy(&mutex)) != 0) {
    /* Handle Error */
  }

  return 0;
}
```

In this example, in each thread created with `pthread_create`, the function `thread_foo` performs a network I/O operation with `recv` after acquiring a lock with `pthread_mutex_lock`. Other threads using the same lock variable `mutex` have to wait for the operation to complete and the lock to become available.

Correction — Perform Blocking Operation Before Acquiring Lock

One possible correction is to call `recv` before acquiring the lock.

```
#include <pthread.h>
#include <sys/socket.h>

pthread_mutexattr_t attr;
pthread_mutex_t mutex;
```

```
void thread_foo(void *ptr) {
  unsigned int num;
  int result;
  int sock;

  /* sock is a connected TCP socket */
  if ((result = recv(sock, (void *)&num, sizeof(unsigned int), 0)) < 0) {
    /* Handle Error */
  }

  if ((result = pthread_mutex_lock(&mutex)) != 0) {
    /* Handle Error */
  }

    /* ... */

  if ((result = pthread_mutex_unlock(&mutex)) != 0) {
    /* Handle Error */
  }
}

int main() {
  pthread_t thread;
  int result;

  if ((result = pthread_mutexattr_settype(
      &attr, PTHREAD_MUTEX_ERRORCHECK)) != 0) {
    /* Handle Error */
  }

  if ((result = pthread_mutex_init(&mutex, &attr)) != 0) {
    /* Handle Error */
  }

  if (pthread_create(&thread, NULL,(void*(*)(void*))& thread_foo, NULL) != 0) {
    /* Handle Error */
  }

  /* ... */

  pthread_join(thread, NULL);

  if ((result = pthread_mutex_destroy(&mutex)) != 0) {
    /* Handle Error */
```

```
  }

  return 0;
}
```

Check Information

Group: Rec. 14. Concurrency (CON)

See Also

External Websites

CON05-C

Introduced in R2019a

Rec. 48. Miscellaneous (MSC)

CERT C: Rec. MSC01-C

Strive for logical completeness

Description

Rule Definition

Strive for logical completeness.

Examples

Missing case for switch condition

Description

Missing case for switch condition occurs when the `switch` variable can take values that are not covered by a `case` statement.

Note Bug Finder only raises a defect if the switch variable is not full range.

Risk

If the `switch` variable takes a value that is not covered by a `case` statement, your program can have unintended behavior.

A switch-statement that makes a security decision is particularly vulnerable when all possible values are not explicitly handled. An attacker can use this situation to deviate the normal execution flow.

Fix

It is good practice to use a `default` statement as a catch-all for values that are not covered by a `case` statement. Even if the `switch` variable takes an unintended value, the resulting behavior can be anticipated.

Example - Missing Default Condition

```
#include <stdio.h>
#include <string.h>

typedef enum E
{
    ADMIN=1,
    GUEST,
    UNKNOWN = 0
} LOGIN;

static LOGIN system_access(const char *username) {
  LOGIN user = UNKNOWN;

  if ( strcmp(username, "root") == 0 )
    user = ADMIN;

  if ( strcmp(username, "friend") == 0 )
    user = GUEST;

  return user;
}

int identify_bad_user(const char * username)
{
    int r=0;

    switch( system_access(username) )
    {
    case ADMIN:
        r = 1;
        break;
    case GUEST:
        r = 2;
    }

    printf("Welcome!\n");
    return r;
}
```

In this example, the `enum` parameter `User` can take a value `UNKNOWN` that is not covered by a `case` statement.

Correction — Add a Default Condition

One possible correction is to add a default condition for possible values that are not covered by a `case` statement.

```
#include <stdio.h>
#include <string.h>

typedef enum E
{
    ADMIN=1,
    GUEST,
    UNKNOWN = 0
} LOGIN;

static LOGIN system_access(const char *username) {
  LOGIN user = UNKNOWN;

  if ( strcmp(username, "root") == 0 )
    user = ADMIN;

  if ( strcmp(username, "friend") == 0 )
    user = GUEST;

  return user;
}

int identify_bad_user(const char * username)
{
    int r=0;

    switch( system_access(username) )
    {
    case ADMIN:
        r = 1;
        break;
    case GUEST:
        r = 2;
    break;
    default:
        printf("Invalid login credentials!\n");
    }

    printf("Welcome!\n");
```

```
    return r;
}
```

Check Information

Group: Rec. 48. Miscellaneous (MSC)

See Also

External Websites

MSC01-C

Introduced in R2019a

CERT C: Rec. MSC04-C

Use comments consistently and in a readable fashion

Description

Rule Definition

Use comments consistently and in a readable fashion.

Examples

Use of /* and // within a comment

Description

The issue occurs when you use the character sequences `/*` and `//` within a comment.

You cannot annotate this rule in the source code. For information on annotations, see .

Risk

These character sequences are not allowed in code comments because:

- If your code contains a `/*` or a `//` in a `/* */` comment, it typically means that you have inadvertently commented out code.
- If your code contains a `/*` in a `//` comment, it typically means that you have inadvertently uncommented a `/* */` comment.

Example - /* Used in // Comments

```
int x;
int y;
int z;

void non_compliant_comments ( void )
```

```
{
    x = y //      /* Non-compliant
        + z
        //  */
        ;
    z++;    //    Compliant with exception: // permitted within a // comment
}

void compliant_comments ( void )
{
    x = y /*      Compliant
      + z
      */
        ;
    z++;    //    Compliant with exception: // is permitted within a // comment
}
```

In this example, in the `non_compliant_comments` function, the `/*` character occurs in what appears to be a `//` comment, violating the rule. Because of the comment structure, the operation that takes place is `x = y + z;`. However, without the two `//`-s, an entirely different operation `x=y;` takes place. It is not clear which operation is intended.

Use a comment format that makes your intention clear. For instance, in the `compliant_comments` function, it is clear that the operation `x=y;` is intended.

Check Information

Group: Rec. 48. Miscellaneous (MSC)

See Also

External Websites

MSC04-C

Introduced in R2019a

CERT C: Rec. MSC12-C

Detect and remove code that has no effect or is never executed

Description

Rule Definition

Detect and remove code that has no effect or is never executed.

Examples

Unreachable code

Description

The issue occurs when your project contains code that is unreachable.

Polyspace Bug Finder and Polyspace Code Prover check this coding rule differently. The analyses can produce different results.

The Code Prover run-time check for unreachable code shows more cases than the MISRA checker for this rule. See also `Unreachable code` in the documentation of the Polyspace Code Prover or Polyspace Code Prover Server products.. The run-time check performs a more exhaustive analysis. In the process, the check can show some instances that are not strictly unreachable code but unreachable only in the context of the analysis. For instance, in the following code, the run-time check shows a potential division by zero in the first line and then removes the zero value of `flag` for the rest of the analysis. Therefore, it considers the `if` block unreachable.

```
val=1.0/flag;
if(!flag) {}
```

The MISRA checker is designed to prevent these kinds of results.

Risk

Unless a program exhibits any undefined behavior, unreachable code cannot execute. The unreachable code cannot affect the program output. The presence of unreachable code can indicate an error in the program logic. Unreachable code that the compiler does not remove wastes resources, for example:

- It occupies space in the target machine memory.
- Its presence can cause a compiler to select longer, slower jump instructions when transferring control around the unreachable code.
- Within a loop, it can prevent the entire loop from residing in an instruction cache.

Example - Code Following `return` Statement

```
enum light { red, amber, red_amber, green };

enum light next_light ( enum light color )
{
    enum light res;

    switch ( color )
    {
    case red:
        res = red_amber;
        break;
    case red_amber:
        res = green;
        break;
    case green:
        res = amber;
        break;
    case amber:
        res = red;
        break;
    default:
    {
        error_handler ();
        break;
    }
    }

    res = color;
    return res;
```

```
    res = color;     /* Non-compliant */
}
```

In this example, the rule is violated because there is an unreachable operation following the `return` statement.

Dead code

Description

The issue occurs when the analysis detects a reachable operation that does not affect program behavior if the operation is removed.

Polyspace Bug Finder detects useless write operations during analysis.

Polyspace Code Prover does not detect useless write operations. For instance, if you assign a value to a local variable but do not read it later, Polyspace Code Prover does not detect this useless assignment. Use Polyspace Bug Finder to detect such useless write operations. For more information, see MISRA C:2012 in Polyspace Bug Finder on page 2-172.

In Code Prover, you can also see a difference in results based on your choice for the option `Verification level (-to)`. . For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

If an operation is reachable but removing the operation does not affect program behavior, the operation constitutes dead code.

The presence of dead code can indicate an error in the program logic. Because a compiler can remove dead code, its presence can cause confusion for code reviewers.

Operations involving language extensions such as `__asm ( "NOP" );` are not considered dead code.

Example - Redundant Operations

```
extern volatile unsigned int v;
extern char *p;
```

```
void f ( void ) {
    unsigned int x;


    ( void ) v;      /* Compliant - Exception*/
    ( int ) v;       /* Non-compliant  */
    v >> 3;          /* Non-compliant  */

    x = 3;           /* Non-compliant - Detected in Bug Finder only */

    *p++;            /* Non-compliant  */
    ( *p )++;        /* Compliant  */
}
```

In this example, the rule is violated when an operation is performed on a variable, but the result of that operation is not used. For instance,

- The operations `(int)` and `>>` on the variable `v` are redundant because the results are not used.
- The operation `=` is redundant because the local variable `x` is not read after the operation.
- The operation `*` on `p++` is redundant because the result is not used.

The rule is not violated when:

- A variable is cast to `void`. The cast indicates that you are intentionally not using the value.
- The result of an operation is used. For instance, the operation `*` on `p` is not redundant, because `*p` is incremented.

Example - Redundant Function Call

```
void g ( void ) {
               /* Compliant  */
}

void h ( void) {
     g( );     /* Non-compliant */
}
```

In this example, `g` is an empty function. Though the function itself does not violate the rule, a call to the function violates the rule.

Check Information

Group: Rec. 48. Miscellaneous (MSC)

See Also

External Websites

MSC12-C

Introduced in R2019a

CERT C: Rec. MSC13-C

Detect and remove unused values

Description

Rule Definition

Detect and remove unused values.

Examples

Unused parameter

Description

Unused parameter occurs when a function parameter is neither read nor written in the function body.

Risk

Unused function parameters cause the following issues:

- Indicate that the code is possibly incomplete. The parameter is possibly intended for an operation that you forgot to code.
- If the copied objects are large, redundant copies can slow down performance.

Fix

Determine if you intend to use the parameters. Otherwise, remove parameters that you do not use in the function body.

You can intentionally have unused parameters. For instance, you have parameters that you intend to use later when you add enhancements to the function. Add a code comment indicating your intention for later use. The code comment helps you or a code reviewer understand why your function has unused parameters.

Alternatively, add a statement such as `(void)var;` in the function body. `var` is the unused parameter. You can define a macro that expands to this statement and add the macro to the function body.

Example - Unused Parameter

```
void func(int* xptr, int* yptr, int flag) {
    if(flag==1) {
        *xptr=0;
    }
    else {
        *xptr=1;
    }
}

int main() {
    int x,y;
    func(&x,&y,1);
    return 0;
}
```

In this example, the parameter `yptr` is not used in the body of `func`.

Correction — Use Parameter

One possible correction is to check if you intended to use the parameter. Fix your code if you intended to use the parameter.

```
void func(int* xptr, int* yptr, int flag) {
    if(flag==1) {
        *xptr=0;
        *yptr=1;
    }
    else {
        *xptr=1;
        *yptr=0;
    }
}

int main() {
    int x,y;
    func(&x,&y,1);
    return 0;
}
```

Correction — Explicitly Indicate Unused Parameter

Another possible correction is to explicitly indicate that you are aware of the unused parameter.

```
#define UNUSED(x) (void)x

void func(int* xptr, int* yptr, int flag) {
    UNUSED(yptr);
    if(flag==1) {
        *xptr=0;
    }
    else {
        *xptr=1;
    }
}

int main() {
    int x,y;
    func(&x,&y,1);
    return 0;
}
```

Write without a further read

Description

Write without a further read occurs when a value assigned to a variable is never read.

For instance, you write a value to a variable and then write a second value before reading the previous value. The first write operation is redundant.

Risk

Redundant write operations often indicate programming errors. For instance, you forgot to read the variable between two successive write operations or unintentionally read a different variable.

Fix

Identify the reason why you write to the variable but do not read it later. Look for common programming errors such as accidentally reading a different variable with a similar name.

If you determine that the write operation is redundant, remove the operation.

Example - Write Without Further Read Error

```
void sensor_amplification(void)
{
    extern int getsensor(void);
    int level;

    level = 4 * getsensor();
    /* Defect: Useless write */
}
```

After the variable `level` gets assigned the value `4 * getsensor()`, it is not read.

Correction — Use Value After Assignment

One possible correction is to use the variable `level` after the assignment.

```
#include <stdio.h>

void sensor_amplification(void)
{
    extern int getsensor(void);
    int level;

    level = 4 * getsensor();

    /* Fix: Use level after assignment */
    printf("The value is %d", level);

}
```

The variable `level` is printed, reading the new value.

Check Information

Group: Rec. 48. Miscellaneous (MSC)

See Also

External Websites

MSC13-C

Introduced in R2019a

CERT C: Rec. MSC15-C

Do not depend on undefined behavior

Description

Rule Definition

Do not depend on undefined behavior.

Examples

Undefined behavior

Description

The issue occurs when the analysis detects undefined or critical unspecified behaviour.

Check Information

Group: Rec. 48. Miscellaneous (MSC)

See Also

External Websites

MSC15-C

Introduced in R2019a

CERT C: Rec. MSC17-C

Finish every set of statements associated with a case label with a break statement

Description

Rule Definition

Finish every set of statements associated with a case label with a break statement.

Examples

Missing break of switch case

Description

Missing break of switch case looks for switch cases that do not end in a `break` statement. If the case does not have a code comment after it, Polyspace assumes the missing break is not intentional and raises a defect.

Risk

Switch cases without break statements fall through to the next switch case. If this fall-through is not intended, the switch case can unintentionally execute code and end the switch with unexpected results.

Fix

If you do not want a break for the highlighted switch case, add a comment to your code to document why this case falls through to the next case. This comment removes the defect from your results and makes your code more maintainable.

If you forgot the break, add it before the end of the switch case.

Example - Switch Without Break Statements

```
enum WidgetEnum { WE_W, WE_X, WE_Y, WE_Z } widget_type;
```

```
extern void demo_do_something_for_WE_W(void);
extern void demo_do_something_for_WE_X(void);
extern void demo_report_error(void);

void bug_missingswitchbreak(enum WidgetEnum wt)
{
    /*
      In this non-compliant code example, the case where widget_type is WE_W lacks a
      break statement. Consequently, statements that should be executed only when
      widget_type is WE_X are executed even when widget_type is WE_W.
    */
    switch (wt)
    {
      case WE_W:
        demo_do_something_for_WE_W();
      case WE_X:
        demo_do_something_for_WE_X();
      default:
        /* Handle error condition */
        demo_report_error();
    }
}
```

In this example, there are two cases without `break` statements. When `wt` is `WE_W`, the statements for `WE_W`, `WE_X`, and the `default` case execute because the program falls through the two cases without a break. No defect is raised on the `default` case or last case because it does not need a break statement.

Correction — Add a Comment or `break`

To fix this example, either add a comment to mark and document the acceptable fall-through or add a break statement to avoid fall-through. In this example, case `WE_W` is supposed to fall through, so a comment is added to explicitly state this action. For the second case, a break statement is added to avoid falling through to the `default` case.

```
enum WidgetEnum { WE_W, WE_X, WE_Y, WE_Z } widget_type;

extern void demo_do_something_for_WE_W(void);
extern void demo_do_something_for_WE_X(void);
extern void demo_report_error(void);

void corrected_missingswitchbreak(enum WidgetEnum wt)
{
    switch (wt)
```

```
    {
      case WE_W:
        demo_do_something_for_WE_W();
        /* fall through to WE_X*/
      case WE_X:
        demo_do_something_for_WE_X();
        break;
      default:
        /* Handle error condition */
        demo_report_error();
    }
}
```

Check Information

Group: Rec. 48. Miscellaneous (MSC)

See Also

External Websites

MSC17-C

Introduced in R2019a

CERT C: Rec. MSC18-C

Be careful while handling sensitive data, such as passwords, in program code

Description

Rule Definition

Be careful while handling sensitive data, such as passwords, in program code.

Examples

Constant block cipher initialization vector

Description

Constant block cipher initialization vector occurs when you use a constant for the initialization vector (IV) during encryption.

Risk

Using a constant IV is equivalent to not using an IV. Your encrypted data is vulnerable to dictionary attacks.

Block ciphers break your data into blocks of fixed size. Block cipher modes such as CBC (Cipher Block Chaining) protect against dictionary attacks by XOR-ing each block with the encrypted output from the previous block. To protect the first block, these modes use a random initialization vector (IV). If you use a constant IV to encrypt multiple data streams that have a common beginning, your data becomes vulnerable to dictionary attacks.

Fix

Produce a random IV by using a strong random number generator.

For a list of random number generators that are cryptographically weak, see `Vulnerable pseudo-random number generator`.

Example - Constants Used for Initialization Vector

```
#include <openssl/evp.h>
#include <stdlib.h>
#define SIZE16 16

/* Using the cryptographic routines */

int func(EVP_CIPHER_CTX *ctx, unsigned char *key){
    unsigned char iv[SIZE16] = {'1', '2', '3', '4','5','6','b','8','9',
                                '1','2','3','4','5','6','7'};
    return EVP_CipherInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv, 1);
}
```

In this example, the initialization vector `iv` has constants only. The constant initialization vector makes your cipher vulnerable to dictionary attacks.

Correction — Use Random Initialization Vector

One possible correction is to use a strong random number generator to produce the initialization vector. The corrected code here uses the function `RAND_bytes` declared in `openssl/rand.h`.

```
#include <openssl/evp.h>
#include <openssl/rand.h>
#include <stdlib.h>
#define SIZE16 16

/* Using the cryptographic routines */

int func(EVP_CIPHER_CTX *ctx, unsigned char *key){
    unsigned char iv[SIZE16];
    RAND_bytes(iv, 16);
    return EVP_CipherInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv, 1);
}
```

Constant cipher key

Description

Constant cipher key occurs when you use a constant for the encryption or decryption key.

Risk

If you use a constant for the encryption or decryption key, an attacker can retrieve your key easily.

You use a key to encrypt and later decrypt your data. If a key is easily retrieved, data encrypted using that key is not secure.

Fix

Produce a random key by using a strong random number generator.

For a list of random number generators that are cryptographically weak, see `Vulnerable pseudo-random number generator`.

Example - Constants Used for Key

```
#include <openssl/evp.h>
#include <stdlib.h>
#define SIZE16 16

int func(EVP_CIPHER_CTX *ctx, unsigned char *iv){
    unsigned char key[SIZE16] = {'1', '2', '3', '4','5','6','b','8','9',
                                 '1','2','3','4','5','6','7'};
    return EVP_CipherInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv, 1);
}
```

In this example, the cipher key, `key`, has constants only. An attacker can easily retrieve a constant key.

Correction — Use Random Key

Use a strong random number generator to produce the cipher key. The corrected code here uses the function `RAND_bytes` declared in `openssl/rand.h`.

```
#include <openssl/evp.h>
#include <openssl/rand.h>
#include <stdlib.h>
#define SIZE16 16

int func(EVP_CIPHER_CTX *ctx, unsigned char *iv){
    unsigned char key[SIZE16];
    RAND_bytes(key, 16);
    return EVP_CipherInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv, 1);
}
```

Predictable block cipher initialization vector

Description

Predictable block cipher initialization vector occurs when you use a weak random number generator for the block cipher initialization vector.

Risk

If you use a weak random number generator for the initiation vector, your data is vulnerable to dictionary attacks.

Block ciphers break your data into blocks of fixed size. Block cipher modes such as CBC (Cipher Block Chaining) protect against dictionary attacks by XOR-ing each block with the encrypted output from the previous block. To protect the first block, these modes use a random initialization vector (IV). If you use a weak random number generator for your IV, your data becomes vulnerable to dictionary attacks.

Fix

Use a strong pseudo-random number generator (PRNG) for the initialization vector. For instance, use:

- OS-level PRNG such as `/dev/random` on UNIX or `CryptGenRandom()` on Windows
- Application-level PRNG such as Advanced Encryption Standard (AES) in Counter (CTR) mode, HMAC-SHA1, etc.

For a list of random number generators that are cryptographically weak, see `Vulnerable pseudo-random number generator`.

Example - Predictable Initialization Vector

```
#include <openssl/evp.h>
#include <openssl/rand.h>
#include <stdlib.h>
#define SIZE16 16

int func(EVP_CIPHER_CTX *ctx, unsigned char *key){
    unsigned char iv[SIZE16];
    RAND_pseudo_bytes(iv, 16);
    return EVP_CipherInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv, 1);
}
```

In this example, the function `RAND_pseudo_bytes` declared in `openssl/rand.h` produces the initialization vector. The byte sequences that `RAND_pseudo_bytes` generates are not necessarily unpredictable.

Correction — Use Strong Random Number Generator

Use a strong random number generator to produce the initialization vector. The corrected code here uses the function `RAND_bytes` declared in `openssl/rand.h`.

```
#include <openssl/evp.h>
#include <openssl/rand.h>
#include <stdlib.h>
#define SIZE16 16

int func(EVP_CIPHER_CTX *ctx, unsigned char *key){
    unsigned char iv[SIZE16];
    RAND_bytes(iv, 16);
    return EVP_CipherInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv, 1);
}
```

Predictable cipher key

Description

Predictable cipher key occurs when you use a weak random number generator for the encryption or decryption key.

Risk

If you use a weak random number generator for the encryption or decryption key, an attacker can retrieve your key easily.

You use a key to encrypt and later decrypt your data. If a key is easily retrieved, data encrypted using that key is not secure.

Fix

Use a strong pseudo-random number generator (PRNG) for the key. For instance:

- Use an OS-level PRNG such as `/dev/random` on UNIX or `CryptGenRandom()` on Windows
- Use an application-level PRNG such as Advanced Encryption Standard (AES) in Counter (CTR) mode, HMAC-SHA1, etc.

For a list of random number generators that are cryptographically weak, see `Vulnerable pseudo-random number generator`.

Example - Predictable Cipher Key

```
#include <openssl/evp.h>
#include <openssl/rand.h>
#include <stdlib.h>
#define SIZE16 16

int func(EVP_CIPHER_CTX *ctx, unsigned char *iv){
    unsigned char key[SIZE16];
    RAND_pseudo_bytes(key, 16);
    return EVP_CipherInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv, 1);
}
```

In this example, the function `RAND_pseudo_bytes` declared in `openssl/rand.h` produces the cipher key. However, the byte sequences that `RAND_pseudo_bytes` generates are not necessarily unpredictable.

Correction — Use Strong Random Number Generator

One possible correction is to use a strong random number generator to produce the cipher key. The corrected code here uses the function `RAND_bytes` declared in `openssl/rand.h`.

```
#include <openssl/evp.h>
#include <openssl/rand.h>
#include <stdlib.h>
#define SIZE16 16

int func(EVP_CIPHER_CTX *ctx, unsigned char *iv){
    unsigned char key[SIZE16];
    RAND_bytes(key, 16);
    return EVP_CipherInit_ex(ctx, EVP_aes_128_cbc(), NULL, key, iv, 1);
}
```

Sensitive heap memory not cleared before release

Description

Sensitive heap memory not cleared before release detects dynamically allocated memory containing sensitive data. If you do not clear the sensitive data when you free the memory, Bug Finder raises a defect on the `free` function.

Risk

If the memory zone is reallocated, an attacker can still inspect the sensitive data in the old memory zone.

Fix

Before calling `free`, clear out the sensitive data using `memset` or `SecureZeroMemory`.

Example - Sensitive Buffer Freed, Not Cleared

```
#include <unistd.h>
#include <stdlib.h>
#include <string.h>
#include <sys/types.h>
#include <pwd.h>

void sensitiveheapnotcleared(const char * my_user) {
    struct passwd* result, pwd;
    long bufsize = sysconf(_SC_GETPW_R_SIZE_MAX);
    char* buf = (char*) malloc(1024);
    getpwnam_r(my_user, &pwd, buf, bufsize, &result);
```

```
    free(buf);
}
```

In this example, the function uses a buffer of passwords and frees the memory before the end of the function. However, the data in the memory is not cleared by using the `free` command.

Correction — Nullify Data

One possible correction is to write over the data to clear out the sensitive information. This example uses `memset` to write over the data with zeros.

```
#include <unistd.h>
#include <stdlib.h>
#include <string.h>
#include <sys/types.h>
#include <pwd.h>
#include <assert.h>

#define isNull(arr) for(int i=0;i<(sizeof(arr)/sizeof(arr[0]));i++) assert(arr[i]==0)

void sensitiveheapnotcleared(const char * my_user) {
    struct passwd* result, pwd;
    long bufsize = sysconf(_SC_GETPW_R_SIZE_MAX);
    char* buf = (char*) malloc(1024);

    if (buf) {
        getpwnam_r(my_user, &pwd, buf, bufsize, &result);
        memset(buf, 0, (size_t)1024);
        isNull(buf);
        free(buf);
    }
}
```

Uncleared sensitive data in stack

Description

Uncleared sensitive data in stack detects static memory containing sensitive data. If you do not clear the sensitive data from your stack before exiting the function or program, Bug Finder raises a defect on the last curly brace.

Risk

Leaving sensitive information in your stack, such as passwords or user information, allows an attacker additional access to the information after your program has ended.

Fix

Before exiting a function or program, clear out the memory zones that contain sensitive data by using `memset` or `SecureZeroMemory`.

Example - Static Buffer of Password Information

```
#include <unistd.h>
#include <sys/types.h>
#include <pwd.h>

void bug_sensitivestacknotcleared(const char * my_user) {
    struct passwd* result, pwd;
    long bufsize = sysconf(_SC_GETPW_R_SIZE_MAX);
    char buf[1024] = "";
    getpwnam_r(my_user, &pwd, buf, bufsize, &result);
}
```

In this example, a static buffer is filled with password information. The program frees the stack memory at the end of the program. However, the data is still accessible from the memory.

Correction — Clear Memory

One possible correction is to write over the memory before exiting the function. This example uses `memset` to clear the data from the buffer memory.

```
#include <unistd.h>
#include <string.h>
#include <sys/types.h>
#include <pwd.h>
#include <assert.h>

#define isNull(arr) for(int i=0; i<(sizeof(arr)/sizeof(arr[0])); i++) assert(arr[i]==0)

void corrected_sensitivestacknotcleared(const char * my_user) {
    struct passwd* result, pwd;
    long bufsize = sysconf(_SC_GETPW_R_SIZE_MAX);
    char buf[1024] = "";
```

```
    getpwnam_r(my_user, &pwd, buf, bufsize, &result);
    memset(buf, 0, (size_t)1024);
    isNull(buf);
}
```

Unsafe standard encryption function

Description

Unsafe standard encryption function detects use of functions with a broken or weak cryptographic algorithm. For example, `crypt` is not reentrant and is based on the risky Data Encryption Standard (DES).

Risk

The use of a broken, weak, or nonstandard algorithm can expose sensitive information to an attacker. A determined hacker can access the protected data using various techniques.

If the weak function is nonreentrant, when you use the function in concurrent programs, there is an additional race condition risk.

Fix

Avoid functions that use these encryption algorithms. Instead, use a reentrant function that uses a stronger encryption algorithm.

Note Some implementations of `crypt` support additional, possibly more secure, encryption algorithms.

Example - Decrypting Password Using `crypt`

```
#define _GNU_SOURCE
#include <pwd.h>
#include <string.h>
#include <crypt.h>

volatile int rd = 1;

const char *salt = NULL;
struct crypt_data input, output;
```

```
int verif_pwd(const char *pwd, const char *cipher_pwd, int safe)
{
    int r = 0;
    char *decrypted_pwd = NULL;

    switch(safe)
    {
      case 1:
        decrypted_pwd = crypt_r(pwd, cipher_pwd, &output);
        break;

      case 2:
        decrypted_pwd = crypt_r(pwd, cipher_pwd, &output);
        break;

      default:
        decrypted_pwd = crypt(pwd, cipher_pwd);
        break;
    }

    r = (strcmp(cipher_pwd, decrypted_pwd) == 0);

    return r;
}
```

In this example, `crypt_r` and `crypt` decrypt a password. However, `crypt` is nonreentrant and uses the unsafe Data Encryption Standard algorithm.

Correction — Use `crypt_r`

One possible correction is to replace `crypt` with `crypt_r`.

```
#define _GNU_SOURCE
#include <pwd.h>
#include <string.h>
#include <crypt.h>

volatile int rd = 1;

const char *salt = NULL;
struct crypt_data input, output;

int verif_pwd(const char *pwd, const char *cipher_pwd, int safe)
{
    int r = 0;
```

```
    char *decrypted_pwd = NULL;

    switch(safe)
    {
      case 1:
        decrypted_pwd = crypt_r(pwd, cipher_pwd, &output);
        break;

      case 2:
        decrypted_pwd = crypt_r(pwd, cipher_pwd, &output);
        break;

      default:
        decrypted_pwd = crypt_r(pwd, cipher_pwd, &output);
        break;
    }

    r = (strcmp(cipher_pwd, decrypted_pwd) == 0);

    return r;
}
```

Check Information

Group: Rec. 48. Miscellaneous (MSC)

See Also

External Websites

MSC18-C

Introduced in R2019a

CERT C: Rec. MSC20-C

Do not use a switch statement to transfer control into a complex block

Description

Rule Definition

Do not use a switch statement to transfer control into a complex block.

Examples

Switch label not at outermost level of body of switch statement

Description

The issue occurs when you use a switch label and the most closely-enclosing compound statement is not the body of the switch statement. For instance a `case` label is enclosed inside a `for` loop that is enclosed inside the switch statement.

Risk

The C Standard permits placing a switch label (for instance, `case` or `default`) before any statement contained in the body of a switch statement. This flexibility can lead to unstructured code. To prevent unstructured code, make sure a switch label appears only at the outermost level of the body of a switch statement.

Check Information

Group: Rec. 48. Miscellaneous (MSC)

See Also

External Websites

MSC20-C

Introduced in R2019a

CERT C: Rec. MSC21-C

Use robust loop termination conditions

Description

Rule Definition

Use robust loop termination conditions.

Examples

Loop bounded with tainted value

Description

Loop bounded with tainted value detects loops that are bounded by values from an unsecure source.

Risk

A tainted value can cause over looping or infinite loops. Attackers can use this vulnerability to crash your program or cause other unintended behavior.

Fix

Before starting the loop, validate unknown boundary and iterator values.

Example - Loop Boundary From Input Argument

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int taintedloopboundary(int count) {
```

```
    int res = 0;
    for (int i=0 ; i < count; ++i) {
        res += i;
    }
    return res;
}
```

In this example, the function uses the input argument to loop `count` times. `count` could be any number because the value is not checked before starting the for-loop.

Correction — Check Loop Control

One possible correction is to check the value of the variable controlling the loop before starting the for-loop. This example checks if `count` is greater than zero and less than the maximum size.

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int taintedloopboundary(int count) {
    int res = 0;

    if (count>0 && count<SIZE128) {
        for (int i=0 ; i<count ; ++i) {
            res += i;
        }
    }
    return res;
}
```

Check Information

Group: Rec. 48. Miscellaneous (MSC)

See Also

External Websites

MSC21-C

Introduced in R2019a

CERT C: Rec. MSC22-C

Use the setjmp(), longjmp() facility securely

Description

Rule Definition

Use the setjmp(), longjmp() facility securely.

Examples

Use of setjmp/longjmp

Description

Use of setjmp/longjmp occurs when you use a combination of `setjmp` and `longjmp` or `sigsetjmp` and `siglongjmp` to deviate from normal control flow and perform non-local jumps in your code.

Risk

Using `setjmp` and `longjmp`, or `sigsetjmp` and `siglongjmp` has the following risks:

- Nonlocal jumps are vulnerable to attacks that exploit common errors such as buffer overflows. Attackers can redirect the control flow and potentially execute arbitrary code.
- Resources such as dynamically allocated memory and open files might not be closed, causing resource leaks.
- If you use `setjmp` and `longjmp` in combination with a signal handler, unexpected control flow can occur. POSIX does not specify whether `setjmp` saves the signal mask.
- Using `setjmp` and `longjmp` or `sigsetjmp` and `siglongjmp` makes your program difficult to understand and maintain.

Fix

Perform nonlocal jumps in your code using `setjmp/longjmp` or `sigsetjmp/siglongjmp` only in contexts where such jumps can be performed securely. Alternatively, use POSIX threads if possible.

In C++, to simulate throwing and catching exceptions, use standard idioms such as `throw` expressions and `catch` statements.

Example - Use of `setjmp` and `longjmp`

```
#include <setjmp.h>
#include <signal.h>

extern int update(int);
extern void print_int(int);

static jmp_buf env;
void sighandler(int signum) {
    longjmp(env, signum);
}
void func_main(int i) {
    signal(SIGINT, sighandler);
    if (setjmp(env)==0) {
        while(1) {
            /* Main loop of program, iterates until SIGINT signal catch */
            i = update(i);
        }
    } else {
        /* Managing longjmp return */
        i = -update(i);
    }

    print_int(i);
    return;
}
```

In this example, the initial return value of `setjmp` is 0. The `update` function is called in an infinite `while` loop until the user interrupts it through a signal.

In the signal handling function, the `longjmp` statement causes a jump back to `main` and the return value of `setjmp` is now 1. Therefore, the `else` branch is executed.

Correction — Use Alternative to `setjmp` and `longjmp`

To emulate the same behavior more securely, use a `volatile` global variable instead of a combination of `setjmp` and `longjmp`.

```
#include <setjmp.h>
#include <signal.h>

extern int update(int);
extern void print_int(int);

volatile sig_atomic_t eflag = 0;

void sighandler(int signum) {
     eflag = signum;                   /* Fix: using global variable */
}

void func_main(int i) {
      /* Fix: Better design to avoid use of setjmp/longjmp */
    signal(SIGINT, sighandler);
    while(!eflag) {                   /* Fix: using global variable */
        /* Main loop of program, iterates until eflag is changed */
        i = update(i);
    }

    print_int(i);
    return;
}
```

Check Information

Group: Rec. 48. Miscellaneous (MSC)

See Also

External Websites

MSC22-C

Introduced in R2019a

CERT C: Rec. MSC24-C

Do not use deprecated or obsolescent functions

Description

Rule Definition

Do not use deprecated or obsolescent functions.

Examples

Use of obsolete standard function

Description

Use of obsolete standard function detects calls to standard function routines that are considered legacy, removed, deprecated, or obsolete by C/C++ coding standards.

Obsolete Function	Standards	Risk	Replacement Function
`asctime`	Deprecated in POSIX.1-2008	Not thread-safe.	`strftime` or `asctime_s`
`asctime_r`	Deprecated in POSIX.1-2008	Implementation based on unsafe function `sprintf`.	`strftime` or `asctime_s`
`bcmp`	Deprecated in 4.3BSD Marked as legacy in POSIX.1-2001.	Returns from function after finding the first differing byte, making it vulnerable to timing attacks.	`memcmp`

Obsolete Function	Standards	Risk	Replacement Function
`bcopy`	Deprecated in 4.3BSD Marked as legacy in POSIX.1-2001.	Returns from function after finding the first differing byte, making it vulnerable to timing attacks.	`memcpy` or `memmove`
`brk` and `sbrk`	Marked as legacy in SUSv2 and POSIX.1-2001.		`malloc`
`bsd_signal`	Removed in POSIX.1-2008		`sigaction`
`bzero`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`memset`
`ctime`	Deprecated in POSIX.1-2008	Not thread-safe.	`strftime` or `asctime_s`
`ctime_r`	Deprecated in POSIX.1-2008	Implementation based on unsafe function `sprintf`.	`strftime` or `asctime_s`
`cuserid`	Removed in POSIX.1-2001.	Not reentrant. Precise functionality not standardized causing portability issues.	`getpwuid`
`ecvt` and `fcvt`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008	Not reentrant	`snprintf`
`ecvt_r` and `fcvt_r`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008		`snprintf`
`ftime`	Removed in POSIX.1-2008		`time`, `gettimeofday`, `clock_gettime`
`gamma`, `gammaf`, `gammal`	Function not specified in any standard because of historical variations	Portability issues.	`tgamma`, `lgamma`

Obsolete Function	Standards	Risk	Replacement Function
`gcvt`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`snprintf`
`getcontext`	Removed in POSIX.1-2008.	Portability issues.	Use POSIX thread instead.
`getdtablesize`	BSD API function not included in POSIX.1-2001	Portability issues.	`sysconf( _SC_OPEN_MAX )`
`gethostbyaddr`	Removed in POSIX.1-2008	Not reentrant	`getaddrinfo`
`gethostbyname`	Removed in POSIX.1-2008	Not reentrant	`getnameinfo`
`getpagesize`	BSD API function not included in POSIX.1-2001	Portability issues.	`sysconf( _SC_PAGESIZE )`
`getpass`	Removed in POSIX.1-2001.	Not reentrant.	`getpwuid`
`getw`	Not present in POSIX.1-2001.		`fread`
`getwd`	Marked legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`getcwd`
`index`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`strchr`
`makecontext`	Removed in POSIX.1-2008.	Portability issues.	Use POSIX thread instead.
`memalign`	Appears in SunOS 4.1.3. Not in 4.4 BSD or POSIX.1-2001		`posix_memalign`
`mktemp`	Removed in POSIX.1-2008.	Generated names are predictable and can cause a race condition.	`mkstemp` removes race risk
`pthread_attr_getstackaddr` and `pthread_attr_setstackaddr`		Ambiguities in the specification of the `stackaddr` attribute cause portability issues	`pthread_attr_getstack` and `pthread_attr_setstack`
`putw`	Not present in POSIX.1-2001.	Portability issues.	`fwrite`

Obsolete Function	Standards	Risk	Replacement Function
`qecvt` and `qfcvt`	Marked as legacy in POSIX.1-2001, removed in POSIX.1-2008		`snprintf`
`qecvt_r` and `qfcvt_r`	Marked as legacy in POSIX.1-2001, removed in POSIX.1-2008		`snprintf`
`rand_r`	Marked as obsolete in POSIX.1-2008		
`re_comp`	BSD API function	Portability issues	`regcomp`
`re_exes`	BSD API function	Portability issues	`regexec`
`rindex`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`strrchr`
`scalb`	Removed in POSIX.1-2008		`scalbln`, `scalblnf`, or `scalblnl`
`sigblock`	4.3BSD signal API whose origin is unclear		`sigprocmask`
`sigmask`	4.3BSD signal API whose origin is unclear		`sigprocmask`
`sigsetmask`	4.3BSD signal API whose origin is unclear		`sigprocmask`
`sigstack`	Interface is obsolete and not implemented on most platforms.	Portability issues.	`sigaltstack`
`sigvec`	4.3BSD signal API whose origin is unclear		`sigaction`
`swapcontext`	Removed in POSIX.1-2008	Portability issues.	Use POSIX threads.

Obsolete Function	Standards	Risk	Replacement Function
`tmpnam` and `tmpnam_r`	Marked as obsolete in POSIX.1-2008.	This function generates a different string each time it is called, up to TMP_MAX times. If it is called more than TMP_MAX times, the behavior is implementation-defined.	`mkstemp`, `tmpfile`
`ttyslot`	Removed in POSIX.1-2001.		
`ualarm`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.	Errors are under-specified	`setitimer` or POSIX `timer_create`
`usleep`	Removed in POSIX.1-2008.		`nanosleep`
`utime`	SVr4, POSIX.1-2001. POSIX.1-2008 marks as obsolete.		
`valloc`	Marked as obsolete in 4.3BSD. Marked as legacy in SUSv2. Removed from POSIX.1-2001		`posix_memalign`
`vfork`	Removed from POSIX.1-2008	Under-specified in previous standards.	`fork`
`wcswcs`	This function was not included in the final ISO/IEC 9899:1990/ Amendment 1:1995 (E).		`wcsstr`
`WinExec`	WinAPI provides this function only for 16-bit Windows compatibility.		`CreateProcess`
`LoadModule`	WinAPI provides this function only for 16-bit Windows compatibility.		`CreateProcess`

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Printing Out Time

```
#include <stdio.h>
#include <time.h>

void timecheck_bad(int argc, char *argv[])
{
    time_t ticks;

    ticks = time(NULL);
    printf("%.24s\r\n", ctime(&ticks));
}
```

In this example, the function `ctime` formats the current time and prints it out. However, `ctime` was removed after C99 because it does not work on multithreaded programs.

Correction — Different Time Function

One possible correction is to use `strftime` instead because this function uses a set buffer size.

```
#include <stdio.h>
#include <string.h>
#include <time.h>

void timecheck_good(int argc, char *argv[])
{
    char outBuff[1025];
    time_t ticks;
    struct tm * timeinfo;

    memset(outBuff, 0, sizeof(outBuff));
```

```
    ticks = time(NULL);
    timeinfo = localtime(&ticks);
    strftime(outBuff,sizeof(outBuff),"%I:%M%p.",timeinfo);
    fprintf(stdout, outBuff);
}
```

Check Information

Group: Rec. 48. Miscellaneous (MSC)

See Also

External Websites

MSC24-C

Introduced in R2019a

Rec. 50. POSIX (POS)

CERT C: Rec. POS05-C

Limit access to files by creating a jail

Description

Rule Definition

Limit access to files by creating a jail.

Examples

File manipulation after chroot without chdir

Description

File manipulation after `chroot()` without `chdir("/")` detects access to the file system outside of the jail created by `chroot`. By calling `chroot`, you create a file system jail that confines access to a specific file subsystem. However, this jail is ineffective if you do not call `chdir("/")`.

Risk

If you do not call `chdir("/")` after creating a `chroot` jail, file manipulation functions that takes a path as an argument can access files outside of the jail. An attacker can still manipulate files outside the subsystem that you specified, making the chroot jail ineffective.

Fix

After calling `chroot`, call `chdir("/")` to make your `chroot` jail more secure.

Example - Open File in `chroot`-jail

```
#include <unistd.h>
#include <stdio.h>
```

```
const char root_path[] = "/var/ftproot";
const char log_path[] = "file.log";
FILE* chrootmisuse() {
    FILE* res;
    chroot(root_path);
    chdir("base");
    res = fopen(log_path, "r");
    return res;
}
```

This example uses `chroot` to create a chroot-jail. However, to use the `chroot` jail securely, you must call `chdir("\")` afterward. This example calls `chdir("base")`, which is not equivalent. Bug Finder also flags `fopen` because `fopen` opens a file in the vulnerable `chroot`-jail.

Correction — Call `chdir("/")`

Before opening files, call `chdir("/")`.

```
#include <unistd.h>
#include <stdio.h>

const char root_path[] = "/var/ftproot";
const char log_path[] = "file.log";
FILE* chrootmisuse() {
    FILE* res;
    chroot(root_path);
    chdir("/");
    res = fopen(log_path, "r");
    return res;
}
```

Check Information

Group: Rec. 50. POSIX (POS)

See Also

External Websites

POS05-C

Introduced in R2019a

Rec. 51. Microsoft Windows (WIN)

CERT C: Rec. WIN00-C

Be specific when dynamically loading libraries

Description

Rule Definition

Be specific when dynamically loading libraries.

Examples

Load of library from a relative path can be controlled by an external actor

Description

Load of library from a relative path can be controlled by an external actor detects library loading routines that load an external library. If you load the library using a relative path or no path, Bug Finder flags the loading routine as a defect.

Risk

By using a relative path or no path to load an external library, your program uses an unsafe search process to find the library. An attacker can control the search process and replace the intended library with a library of their own.

Fix

When you load an external library, specify the full path.

Example - Open Library with Library Name

```
#include <dlfcn.h>
#include <stdlib.h>
#include <string.h>
```

```
#include <malloc.h>
#include <stdio.h>

void relative_path()
{
    dlopen("liberty.dll",RTLD_LAZY);
}
```

In this example, `dlopen` opens the `liberty` library by calling only the name of the library. However, this call to the library uses a relative path to find the library, which is unsafe.

Correction — Use Full Path to Library

One possible correction is to use the full path to the library when you load it into your program.

```
#include <dlfcn.h>
#include <stdlib.h>
#include <string.h>
#include <malloc.h>
#include <stdio.h>

void relative_path()
{
    dlopen("/home/my_libs/library/liberty.dll",RTLD_LAZY);
}
```

Library loaded from externally controlled path

Description

Library loaded from externally controlled path looks for libraries loaded from fixed or controlled paths. If unintended actors can control one or more locations on this fixed path, Bug Finder raises a defect.

Risk

If an attacker knows or controls the path that you use to load a library, the attacker can change:

- The library that the program loads, replacing the intended library and commands.

- The environment in which the library executes, giving unintended permissions and capabilities to the attacker.

Fix

When possible, use hard-coded or fully qualified path names to load libraries. It is possible the hard-coded paths do not work on other systems. Use a centralized location for hard-coded paths, so that you can easily modify the path within the source code.

Another solution is to use functions that require explicit paths. For example, `system()` does not require a full path because it can use the `PATH` environment variable. However, `execl()` and `execv()` do require the full path.

Example - Call Custom Library

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include <unistd.h>
#include <dlfcn.h>
#include <limits.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

void* taintedpathlib() {
    void* libhandle = NULL;
    char lib[SIZE128] = "";
    char* userpath = getenv("LD_LIBRARY_PATH");
    strncpy(lib, userpath, SIZE128);
    strcat(lib, "/libX.so");
    libhandle = dlopen(lib, 0x00001);
    return libhandle;
}
```

This example loads the library `libX.so` from an environment variable `LD_LIBRARY_PATH`. An attacker can change the library path in this environment variable. The actual library you load could be a different library from the one that you intend.

Correction — Change and Check Path

One possible correction is to change how you get the library path and check the path of the library before opening the library. This example receives the path as an input argument. Then the path is checked to make sure the library is not under `/usr/`.

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include <unistd.h>
#include <dlfcn.h>
#include <limits.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

/* Function to sanitize a string */
int sanitize_str(char* s, size_t n) {
    /* strlen is used here as a kind of firewall for tainted string errors */
    int res = (strlen(s) > 0 && strlen(s) < n);
    return res;
}
void* taintedpathlib(char* userpath) {
    void* libhandle = NULL;
    if (sanitize_str(userpath, SIZE128)) {
        char lib[SIZE128] = "";

        if (strncmp(userpath, "/usr", 4)!=0) {
            strncpy(lib, userpath, SIZE128);
            strcat(lib, "/libX.so");
            libhandle = dlopen(lib, RTLD_LAZY);
        }
    }
    return libhandle;
}
```

Check Information

Group: Rec. 51. Microsoft Windows (WIN)

See Also

External Websites

WIN00-C

Introduced in R2019a

5

CERT C++ Rules

Acknowledgement

01. Declarations and Initialization (DCL)

CERT C++: DCL30-C

Declare objects with appropriate storage durations

Description

Rule Definition

Declare objects with appropriate storage durations.

Examples

Pointer or reference to stack variable leaving scope

Description

Pointer or reference to stack variable leaving scope occurs when a pointer or reference to a local variable leaves the scope of the variable. For instance:

- A function returns a pointer to a local variable.
- A function performs the assignment `globPtr = &locVar`. `globPtr` is a global pointer variable and `locVar` is a local variable.
- A function performs the assignment `*paramPtr = &locVar`. `paramPtr` is a function parameter that is, for instance, an `int**` pointer and `locVar` is a local `int` variable.
- A C++ method performs the assignment `memPtr = &locVar`. `memPtr` is a pointer data member of the class the method belongs to. `locVar` is a variable local to the method.

The defect also applies to memory allocated using the `alloca` function. The defect does not apply to static, local variables.

Risk

Local variables are allocated an address on the stack. Once the scope of a local variable ends, this address is available for reuse. Using this address to access the local variable value outside the variable scope can cause unexpected behavior.

If a pointer to a local variable leaves the scope of the variable, Polyspace Bug Finder highlights the defect. The defect appears even if you do not use the address stored in the pointer. For maintainable code, it is a good practice to not allow the pointer to leave the variable scope. Even if you do not use the address in the pointer now, someone else using your function can use the address, causing undefined behavior.

Fix

Do not allow a pointer or reference to a local variable to leave the variable scope.

Example - Pointer to Local Variable Returned from Function

```
void func2(int *ptr) {
    *ptr = 0;
}

int* func1(void) {
    int ret = 0;
    return &ret ;
}
void main(void) {
    int* ptr = func1() ;
    func2(ptr) ;
}
```

In this example, `func1` returns a pointer to local variable `ret`.

In `main`, `ptr` points to the address of the local variable. When `ptr` is accessed in `func2`, the access is illegal because the scope of `ret` is limited to `func1`,

Check Information

Group: 01. Declarations and Initialization (DCL)

See Also

External Websites

DCL30-C

Introduced in R2019a

CERT C++: DCL39-C

Avoid information leakage in structure padding

Description

Rule Definition

Avoid information leakage in structure padding.

Examples

Information leak via structure padding

Description

Information leak via structure padding occurs when you do not initialize the padding data of a structure or union before passing it across a trust boundary. A compiler adds padding bytes to the structure or union to ensure a proper memory alignment of its members. The bit-fields of the storage units can also have padding bits.

Information leak via structure padding raises a defect when:

- You call an untrusted function with structure or union pointer type argument containing uninitialized padding data.

  All external functions are considered untrusted.
- You copy or assign a structure or union containing uninitialized padding data to an untrusted object.

  All external structure or union objects, the output parameters of all externally linked functions, and the return pointer of all external functions are considered untrusted objects.

Risk

The padding bytes of the passed structure or union might contain sensitive information that an untrusted source can access.

Fix

- Prevent the addition of padding bytes for memory alignment by using the `pack` pragma or attribute supported by your compiler.
- Explicitly declare and initialize padding bytes as fields within the structure or union.
- Explicitly declare and initialize bit-fields corresponding to padding bits, even if you use the `pack` pragma or attribute supported by your compiler.

Example - Structure with Padding Bytes Passed to External Function

```
#include <stddef.h>
#include <stdlib.h>
#include <string.h>

typedef struct s_padding
{
 /* Padding bytes may be introduced between
 * 'char c' and 'int i'
 */
        char c;
    int i;

/*Padding bits may be introduced around the bit-fields
* even if you use "#pragma pack" (Windows) or
* __attribute__((__packed__)) (GNU)*/

    unsigned int bf1:1;
    unsigned int bf2:2;
    unsigned char buffer[20];
} S_Padding ;



/* External function */
extern void copy_object(void *out, void *in, size_t s);

void func(void *out_buffer)
{
```

```
/*Padding bytes not initialized*/

    S_Padding s = {'A', 10, 1, 3, {}};
/*Structure passed to external function*/

    copy_object((void *)out_buffer, (void *)&s, sizeof(s));
}

void main(void)
{
    S_Padding s1;
    func(&s1);
}
```

In this example, structure `s1` can have padding bytes between the `char c` and `int i` members. The bit-fields of the storage units of the structure can also contain padding bits. The content of the padding bytes and bits is accessible to an untrusted source when `s1` is passed to `func`.

Correction — Use pack Pragma to Prevent Padding Bytes

One possible correction in Microsoft Visual Studiois to use `#pragma pack()` to prevent padding bytes between the structure members. To prevent padding bits in the bit-fields of `s1`, explicitly declare and initialize the bit-fields even if you use `#pragma pack()`.

```
 #include <stddef.h>
#include <stdlib.h>
#include <string.h>
#include <limits.h>

#define CHAR_BIT 8

#pragma pack(push, 1)

typedef struct s_padding
{
/*No Padding bytes when you use "#pragma pack" (Windows) or
* __attribute__((__packed__)) (GNU)*/
    char c;
    int i;
    unsigned int bf1:1;
    unsigned int bf2:2;
/* Padding bits explicitely declared */
    unsigned int bf_filler : sizeof(unsigned) * CHAR_BIT - 3;
```

```
    unsigned char buffer[20];
}

    S_Padding;

#pragma pack(pop)


/* External function */
extern void copy_object(void *out, void *in, size_t s);



void func(void *out_buffer)
{
    S_Padding s = {'A', 10, 1, 3, 0 /* padding bits */, {}};
    copy_object((void *)out_buffer, (void *)&s, sizeof(s));
}

void main(void)
{
    S_Padding s1;
    func(&s1);
}
```

Check Information

Group: 01. Declarations and Initialization (DCL)

See Also

External Websites

DCL39-C

Introduced in R2019a

CERT C++: DCL40-C

Do not create incompatible declarations of the same function or object

Description

Rule Definition

Do not create incompatible declarations of the same function or object.

Examples

Declaration mismatch

Description

Declaration mismatch occurs when a function or variable declaration does not match other instances of the function or variable.

Risk

When a mismatch occurs between two variable declarations in different compilation units, a typical linker follows an algorithm to pick one declaration for the variable. If you expect a variable declaration that is different from the one chosen by the linker, you can see unexpected results when the variable is used.

A similar issue can occur with mismatch in function declarations.

Fix

The fix depends on the type of declaration mismatch. If both declarations indeed refer to the same object, use the same declaration. If the declarations refer to different objects, change the names of the one of the variables. If you change a variable name, remember to make the change in all places that use the variable.

Sometimes, declaration mismatches can occur because the declarations are affected by previous preprocessing directives. For instance, a declaration occurs in a macro, and the

macro is defined on one inclusion path but undefined in another. These declaration mismatches can be tricky to debug. Identify the divergence between the two inclusion paths and fix the conflicting macro definitions.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Inconsistent Declarations in Two Files

file1.c

```
int foo(void) {
    return 1;
}
```

file2.c

```
double foo(void);

int bar(void) {
    return (int)foo();
}
```

In this example, *file1.c* declares `foo()` as returning an integer. In *file2.c*, `foo()` is declared as returning a double. This difference raises a defect on the second instance of `foo` in *file2*.

Correction — Align the Function Return Values

One possible correction is to change the function declarations so that they match. In this example, by changing the declaration of `foo` in *file2.c* to match *file1.c*, the defect is fixed.

file1.c

```
int foo(void) {
    return 1;
}
```

file2.c

```
int foo(void);

int bar(void) {
    return foo();
}
```

Example - Inconsistent Structure Alignment

test1.c

```
#include "square.h"
#include "circle.h"
struct aCircle circle;
struct aSquare square;

int main(){
    square.side=1;
    circle.radius=1;
    return 0;
}
```

test2.c

```
#include "circle.h"
#include "square.h"
struct aCircle circle;
struct aSquare square;

int main(){
    square.side=1;
    circle.radius=1;
    return 0;
}
```

circle.h

```
#pragma pack(1)

extern struct aCircle{
    int radius;
} circle;
```

square.h

```
extern struct aSquare {
    unsigned int side:1;
} square;
```

In this example, a declaration mismatch defect is raised on `square` in *square.h* because Polyspace infers that `square` in *square.h* does not have the same alignment as `square` in *test2.c*. This error occurs because the `#pragma pack(1)` statement in *circle.h* declares specific alignment. In *test2.c*, *circle.h* is included before *square.h*. Therefore, the `#pragma pack(1)` statement from *circle.h* is not reset to the default alignment after the `aCircle` structure. Because of this omission, *test2.c* infers that the `aSquare square` structure also has an alignment of `1` byte.

Correction — Close Packing Statements

One possible correction is to reset the structure alignment after the `aCircle` struct declaration. For the GNU or Microsoft Visual compilers, fix the defect by adding a `#pragma pack()` statement at the end of *circle.h*.

test1.c	*test2.c*

`#include "square.h"`
`#include "circle.h"`
`struct aCircle circle;`
`struct aSquare square;`
 	
`int main(){`
`  square.side=1;`
`  circle.radius=1;`
`  return 0;`
`}`
	`#include "circle.h"`
	`#include "square.h"`
	`struct aCircle circle;`
	`struct aSquare square;`
	
	`int main(){`
	`  square.side=1;`
	`  circle.radius=1;`
	`  return 0;`
	`}`

circle.h
 	
`#pragma pack(1)`
 	
`extern struct aCircle{`
`  int radius;`
`} circle;`
 	
`#pragma pack()`
	square.h
	
	`extern struct aSquare {`
	`  unsigned int side:1;`
	`} square;`

Other compilers require different `#pragma pack` syntax. For your syntax, see the documentation for your compiler.

Correction — Use the `Ignore pragma pack directives` Option

One possible correction is to add the `Ignore pragma pack directives` option to your Bug Finder analysis. If you want the structure alignment to change for each structure, and you do not want to see this **Declaration mismatch** defect, use this correction.

1. On the Configuration pane, select the **Advanced Settings** pane.
2. In the **Other** box, enter `-ignore-pragma-pack`.
3. Rerun your analysis.

   The **Declaration mismatch** defect is resolved.

Check Information

Group: 01. Declarations and Initialization (DCL)

See Also

External Websites

DCL40-C

Introduced in R2019a

CERT C++: DCL50-CPP

Do not define a C-style variadic function

Description

Rule Definition

Do not define a C-style variadic function.

Examples

Function definition with ellipsis notation

Description

The issue occurs when you define a function using the ellipsis notation.

```
int func( cont char* format, ...);
```

Check Information

Group: 01. Declarations and Initialization (DCL)

See Also

External Websites

DCL50-CPP

Introduced in R2019a

CERT C++: DCL51-CPP

Do not declare or define a reserved identifier

Description

Rule Definition

Do not declare or define a reserved identifier.

Examples

Defining reserved identifier

Description

The issue occurs when you define, redefine, or undefine a reserved identifier, macro, or function in the standard library.

Check Information

Group: 01. Declarations and Initialization (DCL)

See Also

External Websites

DCL51-CPP

Introduced in R2019a

CERT C++: DCL52-CPP

Never qualify a reference type with const or volatile

Description

Rule Definition

Never qualify a reference type with const or volatile.

Examples

`const`-Qualified Reference Type

```
int func (int &const iRef) {
    iRef++;
    return iRef%2;
}
```

In this example, `iRef` is a `const`-qualified reference type. Since `iRef` cannot refer to another variable, the `const` qualifier is redundant.

Correction — Remove `const` Qualifier

Remove the redundant `const` qualifier. Since `iRef` is modified in `func`, it is not meant to refer to a `const`-qualified variable. Moving the `const` qualifier before & will cause a compilation error.

```
int func (int &iRef) {
    iRef++;
    return iRef%2;
}
```

Correction — Fix Placement of `const` Qualifier

If you do not identify to modify `iRef` in `func`, declare `iRef` as a reference to a `const`-qualified variable. Place the `const` qualifier before the & operator. Make sure you do not modify `iRef` in `func`.

```
int func (int const &iRef) {
    return (iRef+1)%2;
}
```

Modification of `const`-qualified Reference Types

```
typedef const int cint;
typedef cint& ref_to_cint;

void func(ref_to_cint refVal, int initVal){
   refVal = val;
}
```

In this example, `ref_to_cint` is a reference to a `const`-qualified type. The variable `refVal` of type `ref_to_cint` is supposed to be initialized when `func` is called and not modified subsequently. The modification violates the contract implied by the `const` qualifier.

Correction — Avoid Modification of `const`-qualified Reference Types

One possible correction is to avoid the `const` in the declaration of the reference type.

```
typedef int& ref_to_int;

void func(ref_to_int refVal, int initVal){
   refVal = val;
}
```

Check Information

Group: 01. Declarations and Initialization (DCL)

See Also

External Websites

DCL52-CPP

Introduced in R2019a

CERT C++: DCL53-CPP

Do not write syntactically ambiguous declarations

Description

Rule Definition

Do not write syntactically ambiguous declarations.

Examples

Function or Object Declaration

```
class ResourceType {
      int aMember;
    public:
      int getMember();
};

void getResource() {
    ResourceType aResource();
}
```

In this example, `aResource` might be used as an object but the declaration syntax indicates a function declaration.

Correction — Use {} for Object Declaration

One possible correction (after C++11) is to use braces for object declaration.

```
class ResourceType {
      int aMember;
    public:
      int getMember();
};
```

```
void getResource() {
    ResourceType aResource{};
}
```

Unnamed Object or Unnamed Function Parameter Declaration

```
class MemberType {};

class ResourceType {
      MemberType aMember;
    public:
      ResourceType(MemberType m) {aMember = m;}
      int getMember();
};

void getResource() {
    ResourceType aResource(MemberType());
}
```

In this example, `aResource` might be used as an object initialized with an unnamed object of type `MemberType` but the declaration syntax indicates a function with an unnamed parameter of function pointer type. The function pointer points to a function with no arguments and type `MemberType`.

Correction — Use {} for Object Declaration

One possible correction (after C++11) is to use braces for object declaration.

```
class MemberType {};

class ResourceType {
      MemberType aMember;
    public:
      ResourceType(MemberType m) {aMember = m;}
      int getMember();
};

void getResource {
    ResourceType aResource{MemberType()};
}
```

Unnamed Object or Named Function Parameter Declaration

```
class Integer {
       int aMember;
    public:
       Integer(int d) {aMember = d;}
       int getMember();
};

int aInt = 0;
Integer aInteger(Integer(aInt));
```

In this example, `aInteger` might be an object constructed with an unnamed object `Integer(aInt)` (an object of class `Integer` which itself is constructed using the variable `aInt`). However, the declaration syntax indicates that `aInteger` is a function with a named parameter `aInt` of type `Integer` (the superfluous parenthesis is ignored).

Correction — Use of {} for Object Declaration

One possible correction (after C++11) is to use {} for object declaration.

```
class Integer {
       int aMember;
    public:
       Integer(int d) {aMember = d;}
       int getMember();
};

int aInt = 0;
Integer aInteger{Integer{aInt}};
```

Correction — Remove Superfluous Parenthesis for Named Parameter Declaration

If `aInteger` is a function with a named parameter `aInt`, remove the superfluous () around `aInt`.

```
class Integer {
       int aMember;
    public:
       Integer(int d) {aMember = d;}
       int getMember();
};

Integer aInteger(Integer aInt);
```

Check Information

Group: 01. Declarations and Initialization (DCL)

See Also

External Websites

DCL53-CPP

Introduced in R2019a

CERT C++: DCL54-CPP

Overload allocation and deallocation functions as a pair in the same scope

Description

Rule Definition

Overload allocation and deallocation functions as a pair in the same scope.

Examples

Mismatch Between Overloaded `operator new` and `operator delete`

```
#include <new>
#include <cstdlib>

int global_store;

void update_bookkeeping(void *allocated_ptr, bool alloc) {
   if(alloc)
      global_store++;
   else
      global_store--;
}


void *operator new(std::size_t size, const std::nothrow_t& tag);
void *operator new(std::size_t size, const std::nothrow_t& tag) {
    void *ptr = (void*)malloc(size);
    if (ptr != nullptr)
        update_bookkeeping(ptr, true);
    return ptr;
}

void operator delete[](void *ptr, const std::nothrow_t& tag);
```

```
void operator delete[](void* ptr, const std::nothrow_t& tag) {
    update_bookkeeping(ptr, false);
    free(ptr);
}
```

In this example, the operators `operator new` and `operator delete[]` are overloaded but there are no overloads of the corresponding `operator delete` and `operator new[]` operators.

The overload of `operator new` calls a function `update_bookkeeping` to change the value of a global variable `global_store`. If the default `operator delete` is called, this global variable is unaffected, which might defy developer's expectations.

Correction — Overload the Correct Form of `operator delete`

If you want to overload `operator new`, overload the corresponding form of `operator delete` in the same scope.

```
#include <new>
#include <cstdlib>

int global_store;

void update_bookkeeping(void *allocated_ptr, bool alloc) {
   if(alloc)
      global_store++;
   else
      global_store--;
}


void *operator new(std::size_t size, const std::nothrow_t& tag);
void *operator new(std::size_t size, const std::nothrow_t& tag) {
    void *ptr = (void*)malloc(size);
    if (ptr != nullptr)
        update_bookkeeping(ptr, true);
    return ptr;
}

void operator delete(void *ptr, const std::nothrow_t& tag);
void operator delete(void* ptr, const std::nothrow_t& tag) {
    update_bookkeeping(ptr, false);
    free(ptr);
}
```

Check Information

Group: 01. Declarations and Initialization (DCL)

See Also

External Websites

DCL54-CPP

Introduced in R2019a

CERT C++: DCL57-CPP

Do not let exceptions escape from destructors or deallocation functions

Description

Rule Definition

Do not let exceptions escape from destructors or deallocation functions.

Examples

Class destructor exiting with an exception

Description

The checker flags exceptions thrown in the body of the destructor. If the destructor calls another function, the checker does not detect if that function throws an exception.

The checker does not detect these situations:

- A `catch` statement does not catch exceptions of all types that are thrown.

  The checker considers the presence of a `catch` statement corresponding to a `try` block as indication that an exception is caught.
- `throw` statements inside `catch` blocks

Check Information

Group: 01. Declarations and Initialization (DCL)

See Also

External Websites

DCL57-CPP

Introduced in R2019a

CERT C++: DCL60-CPP

Obey the one-definition rule

Description

Rule Definition

Obey the one-definition rule.

Examples

Inline constraint not respected

Description

Inline constraint not respected occurs when you refer to a file scope modifiable static variable or define a local modifiable static variable in a nonstatic inlined function. The checker considers a variable as modifiable if it is not `const`-qualified.

For instance, `var` is a modifiable `static` variable defined in an `inline` function `func`. `g_step` is a file scope modifiable static variable referred to in the same inlined function.

```
static int g_step;
inline void func (void) {
   static int var = 0;
   var += g_step;
}
```

Risk

When you modify a static variable in multiple function calls, you expect to modify the same variable in each call. For instance, each time you call `func`, the same instance of `var1` is incremented but a separate instance of `var2` is incremented.

```
void func(void) {
   static var1 = 0;
```

```
   var2 = 0;
   var1++;
   var2++;
}
```

If a function has an inlined and non-inlined definition (in separate files), when you call the function, the C standard allows compilers to use either the inlined or the non-inlined form (see ISO/IEC 9899:2011, sec. 6.7.4). If your compiler uses an inlined definition in one call and the non-inlined definition in another, you are no longer modifying the same variable in both calls. This behavior defies the expectations from a static variable.

Fix

Use one of these fixes:

- If you do not intend to modify the variable, declare it as `const`.

  If you do not modify the variable, there is no question of unexpected modification.
- Make the variable non-`static`. Remove the `static` qualifier from the declaration.

  If the variable is defined in the function, it becomes a regular local variable. If defined at file scope, it becomes an extern variable. Make sure that this change in behavior is what you intend.
- Make the function `static`. Add a `static` qualifier to the function definition.

  If you make the function `static`, the file with the inlined definition always uses the inlined definition when the function is called. Other files use another definition of the function. The question of which function definition gets used is not left to the compiler.

Example - Static Variable Use in Inlined and External Definition

```
/* file1. c  : contains inline definition of get_random()*/

inline unsigned int get_random(void)
{

    static unsigned int m_z = 0xdeadbeef;
    static unsigned int m_w = 0xbaddecaf;

    /* Compute next pseudorandom value and update seeds */
    m_z = 36969 * (m_z & 65535) + (m_z >> 16);
    m_w = 18000 * (m_w & 65535) + (m_w >> 16);
    return (m_z << 16) + m_w;
```

```
}


int call_get_random(void)
{
    unsigned int rand_no;
    int ii;
    for (ii = 0; ii < 100; ii++) {
         rand_no = get_random();
    }
    rand_no = get_random();
    return 0;
}

/* file2. c  : contains external definition of get_random()*/

extern unsigned int get_random(void)
{
    /* Initialize seeds */
    static unsigned int m_z = 0xdeadbeef;
    static unsigned int m_w = 0xbaddecaf;

    /* Compute next pseudorandom value and update seeds */
    m_z = 36969 * (m_z & 65535) + (m_z >> 16);
    m_w = 18000 * (m_w & 65535) + (m_w >> 16);
    return (m_z << 16) + m_w;
}
```

In this example, `get_random()` has an inline definition in `file1.c` and an external definition in `file2.c`. When `get_random` is called in `file1.c`, compilers are free to choose whether to use the inline or the external definition.

Depending on the definition used, you might or might not modify the version of `m_z` and `m_w` in the inlined version of `get_random()`. This behavior contradicts the usual expectations from a static variable. When you call `get_random()`, you expect to always modify the same `m_z` and `m_w`.

Correction — Make Inlined Function Static

One possible correction is to make the inlined `get_random()` static. Irrespective of your compiler, calls to `get_random()` in `file1.c` then use the inlined definition. Calls to `get_random()` in other files use the external definition. This fix removes the ambiguity about which definition is used and whether the static variables in that definition are modified.

```
/* file1. c  : contains inline definition of get_random()*/

static inline unsigned int get_random(void)
{

    static unsigned int m_z = 0xdeadbeef;
    static unsigned int m_w = 0xbaddecaf;

    /* Compute next pseudorandom value and update seeds */
    m_z = 36969 * (m_z & 65535) + (m_z >> 16);
    m_w = 18000 * (m_w & 65535) + (m_w >> 16);
    return (m_z << 16) + m_w;
}


int call_get_random(void)
{
    unsigned int rand_no;
    int ii;
    for (ii = 0; ii < 100; ii++) {
         rand_no = get_random();
    }
    rand_no = get_random();
    return 0;
}

/* file2. c  : contains external definition of get_random()*/

extern unsigned int get_random(void)
{
    /* Initialize seeds */
    static unsigned int m_z = 0xdeadbeef;
    static unsigned int m_w = 0xbaddecaf;

    /* Compute next pseudorandom value and update seeds */
    m_z = 36969 * (m_z & 65535) + (m_z >> 16);
    m_w = 18000 * (m_w & 65535) + (m_w >> 16);
    return (m_z << 16) + m_w;
}
```

Check Information

Group: 01. Declarations and Initialization (DCL)

See Also

External Websites

DCL60-CPP

Introduced in R2019a

02. Expressions (EXP)

CERT C++: EXP34-C

Do not dereference null pointers

Description

Rule Definition

Do not dereference null pointers.

Examples

Null pointer

Description

Null pointer occurs when you use a pointer with a value of `NULL` as if it points to a valid memory location.

Risk

Dereferencing a null pointer is undefined behavior. In most implementations, the dereference can cause your program to crash.

Fix

Check a pointer for `NULL` before dereference.

If the issue occurs despite an earlier check for `NULL`, look for intermediate events between the check and the subsequent dereference. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

Example - Null pointer error

```
#include <stdlib.h>

int FindMax(int *arr, int Size)
{
 int* p=NULL;

 *p=arr[0];
 /* Defect: Null pointer dereference */

 for(int i=0;i<Size;i++)
  {
   if(arr[i] > (*p))
     *p=arr[i];
  }

 return *p;
}
```

The pointer `p` is initialized with value of `NULL`. However, when the value `arr[0]` is written to `*p`, `p` is assumed to point to a valid memory location.

Correction — Assign Address to Null Pointer Before Dereference

One possible correction is to initialize `p` with a valid memory address before dereference.

```
#include <stdlib.h>

int FindMax(int *arr, int Size)
{
 /* Fix: Assign address to null pointer */
 int* p=&arr[0];

 for(int i=0;i<Size;i++)
  {
   if(arr[i] > (*p))
     *p=arr[i];
  }

 return *p;
}
```

Check Information

Group: 02. Expressions (EXP)

See Also

External Websites

EXP34-C

Introduced in R2019a

CERT C++: EXP35-C

Do not modify objects with temporary lifetime

Description

Rule Definition

Do not modify objects with temporary lifetime.

Examples

Accessing object with temporary lifetime

Description

Accessing object with temporary lifetime occurs when you attempt to read from or write to an object with temporary lifetime that is returned by a function call. In a structure or union returned by a function, and containing an array, the array members are temporary objects. The lifetime of temporary objects ends:

- When the full expression or full declarator containing the call ends, as defined in the C11 Standard.
- After the next sequence point, as defined in the C90 and C99 Standards. A sequence point is a point in the execution of a program where all previous evaluations are complete and no subsequent evaluation has started yet.

For C++ code, **Accessing object with temporary lifetime** raises a defect only when you write to an object with a temporary lifetime.

If the temporary lifetime object is returned by address, no defect is raised.

Risk

Modifying objects with temporary lifetime is undefined behavior and can cause abnormal program termination and portability issues.

Fix

Assign the object returned from the function call to a local variable. The content of the temporary lifetime object is copied to the variable. You can now modify it safely.

Example - Modifying Temporary Lifetime Object Returned by Function Call

```
#include <stdio.h>
#include <assert.h>
#include <stdlib.h>
#include <string.h>

#define SIZE6 6

struct S_Array
{
    int t;
    int a[SIZE6];
};

struct S_Array func_temp(void);

/* func_temp() returns a struct value containing
* an array with a temporary lifetime.
*/
int func(void) {

/*Writing to temporary lifetime object is
 undefined behavior
 */
    return ++(func_temp().a[0]);
}

void main(void) {
    (void)func();
}
```

In this example, `func_temp()` returns by value a structure with an array member `a`. This member has temporary lifetime. Incrementing it is undefined behavior.

Correction — Assign Returned Value to Local Variable Before Writing

One possible correction is to assign the return of the call to `func_temp()` to a local variable. The content of the temporary object `a` is copied to the variable, which you can safely increment.

```
 #include <stdio.h>
#include <assert.h>
#include <stdlib.h>
#include <string.h>

#define SIZE6 6

struct S_Array
{
    int t;
    int a[SIZE6];
};

struct S_Array func_temp(void);

int func(void) {

/* Assign object returned by function call to
 *local variable
 */
    struct S_Array s = func_temp();

/* Local variable can safely be
 *incremented
 */
    ++(s.a[0]);
    return s.a[0];
}

void main(void) {
    (void)func();
}
```

Check Information

Group: 02. Expressions (EXP)

See Also

External Websites

EXP35-C

Introduced in R2019a

CERT C++: EXP36-C

Do not cast pointers into more strictly aligned pointer types

Description

Rule Definition

Do not cast pointers into more strictly aligned pointer types.

Examples

Wrong allocated object size for cast

Description

Wrong allocated object size for cast occurs during pointer conversion when the pointer's address is misaligned. If a pointer is converted to a different pointer type, the size of the allocated memory must be a multiple of the size of the destination pointer.

Risk

Dereferencing a misaligned pointer has undefined behavior and can cause your program to crash.

Fix

Suppose you convert a pointer `ptr1` to `ptr2`. If `ptr1` points to a buffer of `N` bytes and `ptr2` is a *`type`* `*` pointer where `sizeof(`*`type`*`)` is `n` bytes, make sure that `N` is an integer multiple of `n`.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See "Address Polyspace Results Through Bug Fixes or Comments".

Example - Dynamic Allocation of Pointers

```
#include <stdlib.h>

void dyn_non_align(void){
    void *ptr = malloc(13);
    long *dest;

    dest = (long*)ptr; //defect
}
```

In this example, the software raises a defect on the conversion of `ptr` to a `long*`. The dynamically allocated memory of `ptr`, 13 bytes, is not a multiple of the size of `dest`, 4 bytes. This misalignment causes the **Wrong allocated object size for cast** defect.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the allocated memory to 12 instead of 13.

```
#include <stdlib.h>

void dyn_non_align(void){
    void *ptr = malloc(12);
    long *dest;

    dest = (long*)ptr;
}
```

Example - Static Allocation of Pointers

```
void static_non_align(void){
    char arr[13], *ptr;
    int *dest;

    ptr = &arr[0];
    dest = (int*)ptr; //defect
}
```

In this example, the software raises a defect on the conversion of `ptr` to an `int*` in line 6. `ptr` has a memory size of 13 bytes because the array `arr` has a size of 13 bytes. The size of `dest` is 4 bytes, which is not a multiple of 13. This misalignment causes the **Wrong allocated object size for cast** defect.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the size of the array `arr` to a multiple of 4.

```
void static_non_align(void){
    char arr[12], *ptr;
    int *dest;

    ptr = &arr[0];
    dest = (int*)ptr;
}
```

Example - Allocation with a Function

```
#include <stdlib.h>

void *my_alloc(int size) {
    void *ptr_func = malloc(size);
    if(ptr_func == NULL) exit(-1);
    return ptr_func;
}

void fun_non_align(void){
    int *dest1;
    char *dest2;

    dest1 = (int*)my_alloc(13);  //defect
    dest2 = (char*)my_alloc(13); //not a defect
}
```

In this example, the software raises a defect on the conversion of the pointer returned by `my_alloc(13)` to an `int*` in line 11. `my_alloc(13)` returns a pointer with a dynamically allocated size of 13 bytes. The size of `dest1` is 4 bytes, which is not a divisor of 13. This misalignment causes the **Wrong allocated object size for cast** defect. In line 12, the same function call, `my_alloc(13)`, does not call a defect for the conversion to `dest2` because the size of `char*`, 1 byte, a divisor of 13.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the argument for `my_alloc` to a multiple of 4.

```
#include <stdlib.h>

void *my_alloc(int size) {
    void *ptr_func = malloc(size);
    if(ptr_func == NULL) exit(-1);
    return ptr_func;
}

void fun_non_align(void){
    int *dest1;
    char *dest2;

    dest1 = (int*)my_alloc(12);
    dest2 = (char*)my_alloc(13);
}
```

Check Information

Group: 02. Expressions (EXP)

See Also

External Websites

EXP36-C

Introduced in R2019a

CERT C++: EXP37-C

Call functions with the correct number and type of arguments

Description

Rule Definition

Call functions with the correct number and type of arguments.

Examples

Bad file access mode or status

Description

Bad file access mode or status occurs when you use functions in the `fopen` or `open` group with invalid or incompatible file access modes, file creation flags, or file status flags as arguments. For instance, for the `open` function, examples of valid:

- Access modes include `O_RDONLY`, `O_WRONLY`, and `O_RDWR`
- File creation flags include `O_CREAT`, `O_EXCL`, `O_NOCTTY`, and `O_TRUNC`.
- File status flags include `O_APPEND`, `O_ASYNC`, `O_CLOEXEC`, `O_DIRECT`, `O_DIRECTORY`, `O_LARGEFILE`, `O_NOATIME`, `O_NOFOLLOW`, `O_NONBLOCK`, `O_NDELAY`, `O_SHLOCK`, `O_EXLOCK`, `O_FSYNC`, `O_SYNC` and so on.

The defect can occur in the following situations.

Situation	Risk	Fix
You pass an empty or invalid access mode to the `fopen` function. According to the ANSI C standard, the valid access modes for `fopen` are: • `r`,`r+` • `w`,`w+` • `a`,`a+` • `rb`, `wb`, `ab` • `r+b`, `w+b`, `a+b` • `rb+`, `wb+`, `ab+`	`fopen` has undefined behavior for invalid access modes. Some implementations allow extension of the access mode such as: • GNU: `rb +cmxe,ccs=utf` • Visual C++: `a+t`, where `t` specifies a text mode. However, your access mode string must begin with one of the valid sequences.	Pass a valid access mode to `fopen`.
You pass the status flag `O_APPEND` to the `open` function without combining it with either `O_WRONLY` or `O_RDWR`.	`O_APPEND` indicates that you intend to add new content at the end of a file. However, without `O_WRONLY` or `O_RDWR`, you cannot write to the file. The `open` function does not return -1 for this logical error.	Pass either `O_APPEND|O_WRONLY` or `O_APPEND|O_RDWR` as access mode.
You pass the status flags `O_APPEND` and `O_TRUNC` together to the `open` function.	`O_APPEND` indicates that you intend to add new content at the end of a file. However, `O_TRUNC` indicates that you intend to truncate the file to zero. Therefore, the two modes cannot operate together. The `open` function does not return -1 for this logical error.	Depending on what you intend to do, pass one of the two modes.

Situation	Risk	Fix
You pass the status flag `O_ASYNC` to the `open` function.	On certain implementations, the mode `O_ASYNC` does not enable signal-driven I/O operations.	Use the `fcntl(pathname, F_SETFL, O_ASYNC);` instead.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Invalid Access Mode with `fopen`

```
#include <stdio.h>

void func(void) {
    FILE *file = fopen("data.txt", "rw");
    if(file!=NULL) {
        fputs("new data",file);
        fclose(file);
    }
}
```

In this example, the access mode `rw` is invalid. Because `r` indicates that you open the file for reading and `w` indicates that you create a new file for writing, the two access modes are incompatible.

Correction — Use Either `r` or `w` as Access Mode

One possible correction is to use the access mode corresponding to what you intend to do.

```
#include <stdio.h>

void func(void) {
    FILE *file = fopen("data.txt", "w");
    if(file!=NULL) {
```

```
        fputs("new data",file);
        fclose(file);
    }
}
```

Unreliable cast of function pointer

Description

Unreliable cast of function pointer occurs when a function pointer is cast to another function pointer that has different argument or return type.

This defect applies only if the code language for the project is C.

Risk

If you cast a function pointer to another function pointer with different argument or return type and then use the latter function pointer to call a function, the behavior is undefined.

Fix

Avoid a cast between two function pointers with mismatch in argument or return types.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Unreliable cast of function pointer error

```
#include <stdio.h>
#include <math.h>
#include <stdio.h>
#define PI 3.142

double Calculate_Sum(int (*fptr)(double))
{
    double  sum = 0.0;
    double  y;

    for (int i = 0;  i <= 100;  i++)
    {
```

```
        y = (*fptr)(i*PI/100);
        sum += y;
    }
    return sum / 100;
}

int main(void)
{
    double  (*fp)(double);
    double  sum;

    fp = sin;
    sum = Calculate_Sum(fp);
    /* Defect: fp implicitly cast to int(*) (double) */

    printf("sum(sin): %f\n", sum);
    return 0;
}
```

The function pointer `fp` is declared as `double (*)(double)`. However in passing it to function `Calculate_Sum`, `fp` is implicitly cast to `int (*)(double)`.

Correction — Avoid Function Pointer Cast

One possible correction is to check that the function pointer in the definition of `Calculate_Sum` has the same argument and return type as `fp`. This step makes sure that `fp` is not implicitly cast to a different argument or return type.

```
#include <stdio.h>
#include <math.h>
#include <stdio.h>
# define PI 3.142

/*Fix: fptr has same argument and return type everywhere*/
double Calculate_Sum(double (*fptr)(double))
{
    double  sum = 0.0;
    double y;

    for (int i = 0;  i <= 100;  i++)
    {
        y = (*fptr)(i*PI/100);
        sum += y;
    }
```

```
    return sum / 100;
}

int main(void)
{
    double  (*fp)(double);
    double  sum;


    fp = sin;
    sum = Calculate_Sum(fp);
    printf("sum(sin): %f\n", sum);

    return 0;
}
```

Standard function call with incorrect arguments

Description

Standard function call with incorrect arguments occurs when the arguments to certain standard functions do not meet the requirements for their use in the functions.

For instance, the arguments to these functions can be invalid in the following ways.

Function Type	Situation	Risk	Fix
String manipulation functions such as `strlen` and `strcpy`	The pointer arguments do not point to a `NULL`-terminated string.	The behavior of the function is undefined.	Pass a `NULL`-terminated string to string manipulation functions.
File handling functions in `stdio.h` such as `fputc` and `fread`	The `FILE*` pointer argument can have the value `NULL`.	The behavior of the function is undefined.	Test the `FILE*` pointer for `NULL` before using it as function argument.

Function Type	Situation	Risk	Fix
File handling functions in `unistd.h` such as `lseek` and `read`	The file descriptor argument can be -1.	The behavior of the function is undefined. Most implementations of the `open` function return a file descriptor value of -1. In addition, they set `errno` to indicate that an error has occurred when opening a file.	Test the return value of the `open` function for -1 before using it as argument for `read` or `lseek`. If the return value is -1, check the value of `errno` to see which error has occurred.
	The file descriptor argument represents a closed file descriptor.	The behavior of the function is undefined.	Close the file descriptor only after you have completely finished using it. Alternatively, reopen the file descriptor before using it as function argument.
Directory name generation functions such as `mkdtemp` and `mkstemps`	The last six characters of the string template are not XXXXXX.	The function replaces the last six characters with a string that makes the file name unique. If the last six characters are not XXXXXX, the function cannot generate a unique enough directory name.	Test if the last six characters of a string are XXXXXX before using the string as function argument.

Function Type	Situation	Risk	Fix
Functions related to environment variables such as `getenv` and `setenv`	The string argument is `""`.	The behavior is implementation-defined.	Test the string argument for `""` before using it as `getenv` or `setenv` argument.
	The string argument terminates with an equal sign, =. For instance, `"C="` instead of `"C"`.	The behavior is implementation-defined.	Do not terminate the string argument with =.
String handling functions such as `strtok` and `strstr`	• `strtok`: The delimiter argument is `""`. • `strstr`: The search string argument is `""`.	Some implementations do not handle these edge cases.	Test the string for `""` before using it as function argument.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - NULL Pointer Passed as `strnlen` Argument

```
#include <string.h>
#include <stdlib.h>

enum {
    SIZE10 = 10,
    SIZE20 = 20
};
```

```
int func() {
    char* s = NULL;
    return strnlen(s, SIZE20);
}
```

In this example, a `NULL` pointer is passed as `strnlen` argument instead of a `NULL`-terminated string.

Before running analysis on the code, specify a GNU compiler. See `Compiler (-compiler)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Correction — Pass NULL-terminated String

Pass a `NULL`-terminated string as the first argument of `strnlen`.

```
#include <string.h>
#include <stdlib.h>

enum {
    SIZE10 = 10,
    SIZE20 = 20
};

int func() {
    char* s = "";
    return strnlen(s, SIZE20);
}
```

Check Information

Group: 02. Expressions (EXP)

See Also

External Websites

EXP37-C

Introduced in R2019a

CERT C++: EXP39-C

Do not access a variable through a pointer of an incompatible type

Description

Rule Definition

Do not access a variable through a pointer of an incompatible type.

Examples

Pointer conversion to unrelated pointer type

Description

The checker flags all pointer conversions including between a pointer to a `struct` object and a pointer to the first member of the same `struct` type.

Indirect conversions from a pointer to non-pointer type are not detected.

Check Information

Group: 02. Expressions (EXP)

See Also

External Websites

EXP39-C

Introduced in R2019a

CERT C++: EXP42-C

Do not compare padding data

Description

Rule Definition

Do not compare padding data.

Examples

Memory comparison of padding data

Description

Memory comparison of padding data occurs when you use the `memcmp` function to compare two structures as a whole. In the process, you compare meaningless data stored in the structure padding.

For instance:

```
struct structType {
    char member1;
    int member2;
    .
    .
};

structType var1;
structType var2;
.
.
if(memcmp(&var1,&var2,sizeof(var1)))
{...}
```

Risk

If members of a structure have different data types, your compiler introduces additional padding for data alignment in memory. For an example of padding, see `Higher Estimate of Local Variable Size`.

The content of these extra padding bytes is meaningless. The C Standard allows the content of these bytes to be indeterminate, giving different compilers latitude to implement their own padding. If you perform a byte-by-byte comparison of structures with `memcmp`, you compare even the meaningless data stored in the padding. You might reach the false conclusion that two data structures are not equal, even if their corresponding members have the same value.

Fix

Instead of comparing two structures in one attempt, compare the structures member by member.

For efficient code, write a function that does the comparison member by member. Use this function for comparing two structures.

You can use `memcmp` for byte-by-byte comparison of structures only if you know that the structures do not contain padding. Typically, to prevent padding, you use specific attributes or pragmas such as `#pragma pack`. However, these attributes or pragmas are not supported by all compilers and make your code implementation-dependent. If your structures contain bit-fields, using these attributes or pragmas cannot prevent padding.

Example - Structures Compared with `memcmp`

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define fatal_error() abort()

typedef struct s_padding
{
    char c;
    int i;
    unsigned int bf1:1;
    unsigned int bf2:2;
    unsigned char buffer[20];
} S_Padding ;
```

```
/* Function that guarantees safe access to the input memory */
extern int trusted_memory_zone(void *ptr, size_t sz);

int func(const S_Padding *left, const S_Padding *right)
{

    if (!trusted_memory_zone((void *)left, sizeof(S_Padding)) ||
        !trusted_memory_zone((void *)right, sizeof(S_Padding))) {
        fatal_error();
    }

    if (0 == memcmp(left, right, sizeof(S_Padding)))
    {
        return 1;
    }
    else
        return 0;
}
```

In this example, `memcmp` compares byte-by-byte the two structures that `left` and `right` point to. Even if the values stored in the structure members are the same, the comparison can show an inequality if the meaningless values in the padding bytes are not the same.

Correction — Compare Structures Member by Member

One possible correction is to compare individual structure members.

Note You can compare entire arrays by using `memcmp`. All members of an array have the same data type. Padding bytes are not required to store arrays.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define fatal_error() abort()

typedef struct s_padding
{
    char c;
    int i;
    unsigned int bf1:1;
```

```
    unsigned int bf2:2;
    unsigned char buffer[20];
} S_Padding ;

/* Function that guarantees safe access to the input memory */
extern int trusted_memory_zone(void *ptr, size_t sz);

int func(const S_Padding *left, const S_Padding *right)
{
    if (!trusted_memory_zone((void *)left, sizeof(S_Padding)) ||
        !trusted_memory_zone((void *)right, sizeof(S_Padding))) {
        fatal_error();
    }

    return ((left->c == right->c) &&
            (left->i == right->i) &&
            (left->bf1 == right->bf1) &&
            (left->bf2 == right->bf2) &&
            (memcmp(left->buffer, right->buffer, 20) == 0));
}
```

Check Information

Group: 02. Expressions (EXP)

See Also

External Websites

EXP42-C

Introduced in R2019a

CERT C++: EXP45-C

Do not perform assignments in selection statements

Description

Rule Definition

Do not perform assignments in selection statements.

Examples

Invalid use of = (assignment) operator

Description

Invalid use of = operator occurs when an assignment is made inside the predicate of a conditional, such as `if` or `while`.

In C and C++, a single equal sign is an assignment not a comparison. Using a single equal sign in a conditional statement can indicate a typo or a mistake.

Risk

- Conditional statement tests the wrong values— The single equal sign operation assigns the value of the right operand to the left operand. Then, because this assignment is inside the predicate of a conditional, the program checks whether the new value of the left operand is nonzero or not NULL.
- Maintenance and readability issues — Even if the assignment is intended, someone reading or updating the code can misinterpret the assignment as an equality comparison instead of an assignment.

Fix

- If the assignment is a bug, to check for equality, add a second equal sign (==).

- If the assignment inside the conditional statement was intentional, to improve readability, separate the assignment and the test. Move the assignment outside the control statement. In the control statement, simply test the result of the assignment.

  If you do not want to fix the issue, add comments to your result or code to avoid another review. See "Address Polyspace Results Through Bug Fixes or Comments".

Example - Single Equal Sign Inside an `if` Condition

```
#include <stdio.h>

void bad_equals_ex(int alpha, int beta)
{
    if(alpha = beta)
    {
        printf("Equal\n");
    }
}
```

The equal sign is flagged as a defect because the assignment operator is used within the predicate of the if-statement. The predicate assigns the value `beta` to `alpha`, then implicitly tests whether `alpha` is true or false.

Correction — Change Expression to Comparison

One possible correction is adding an additional equal sign. This correction changes the assignment to a comparison. The if condition compares whether `alpha` and `beta` are equal.

```
#include <stdio.h>

void equality_test(int alpha, int beta)
{
    if(alpha == beta)
    {
        printf("Equal\n");
    }
}
```

Correction — Assignment and Comparison Inside the `if` Condition

If an assignment must be made inside the predicate, a possible correction is adding an explicit comparison. This correction assigns the value of `beta` to `alpha`, then explicitly checks whether `alpha` is nonzero. The code is clearer.

```
#include <stdio.h>

int assignment_not_zero(int alpha, int beta)
{
    if((alpha = beta) != 0)
    {
        return alpha;
    }
    else
    {
        return 0;
    }
}
```

Correction — Move Assignment Outside the `if` Statement

If the assignment can be made outside the control statement, one possible correction is to separate the assignment and comparison. This correction assigns the value of `beta` to `alpha` before the if. Inside the if-condition, only `alpha` is given to test if `alpha` is nonzero or not NULL.

```
#include <stdio.h>

void assign_and_print(int alpha, int beta)
{
    alpha = beta;
    if(alpha)
    {
        printf("%d", alpha);
    }
}
```

Check Information

Group: 02. Expressions (EXP)

See Also

External Websites

EXP45-C

Introduced in R2019a

CERT C++: EXP46-C

Do not use a bitwise operator with a Boolean-like operand

Description

Rule Definition

Do not use a bitwise operator with a Boolean-like operand.

Examples

Use of `bool` operand with bitwise operator

Description

The issue occurs when you use expressions with type `bool` as operands to built-in operators except for:

- The assignment operator =.
- The logical operators &&, ||, and !.
- The equality operators == and !=.
- The unary operator &.
- The conditional operator.

Risk

Operators other than the ones mentioned in the rule do not produce meaningful results with `bool` operands. Use of `bool` operands with these operators can indicate programming errors. For instance, you intended to use the logical operator `||` but used the bitwise operator `|` instead.

Example - Compliant and Noncompliant Uses of `bool` Operands

```
void boolOperations() {
    bool lhs = true;
```

```
    bool rhs = false;

    int res;

    if(lhs & rhs) {} //Noncompliant
    if(lhs < rhs) {} //Noncompliant
    if(~rhs) {}      //Noncompliant
    if(lhs ^ rhs) {} //Noncompliant
    if(lhs == rhs) {} //Compliant
    if(!rhs) {}       //Compliant
    res = lhs? -1:1;  //Compliant
}
```

In this example, `bool` operands do not violate the rule when used with the `==`, `!` and the `?` operators.

Check Information

Group: 02. Expressions (EXP)

See Also

External Websites

EXP46-C

Introduced in R2019a

CERT C++: EXP47-C

Do not call va_arg with an argument of the incorrect type

Description

Rule Definition

Do not call va_arg with an argument of the incorrect type.

Examples

Incorrect data type passed to va_arg

Description

Incorrect data type passed to va_arg when the data type in a `va_arg` call does not match the data type of the variadic function argument that `va_arg` reads.

For instance, you pass an `unsigned char` argument to a variadic function `func`. Because of default argument promotion, the argument is promoted to `int`. When you use a `va_arg` call that reads an `unsigned char` argument, a type mismatch occurs.

```
void func (int n, ...) {
   ...
   va_list args;
   va_arg(args, unsigned char);
   ...
}

void main(void) {
   unsigned char c;
   func(1,c);
}
```

Risk

In a variadic function (function with variable number of arguments), you use `va_arg` to read each argument from the variable argument list (`va_list`). The `va_arg` use does not guarantee that there actually exists an argument to read or that the argument data type matches the data type in the `va_arg` call. You have to make sure that both conditions are true.

Reading an incorrect type with a `va_arg` call can result in undefined behavior. Because function arguments reside on the stack, you might access an unwanted area of the stack.

Fix

Make sure that the data type of the argument passed to the variadic function matches the data type in the `va_arg` call.

Arguments of a variadic function undergo default argument promotions. The argument data types of a variadic function cannot be determined from a prototype. The arguments of such functions undergo default argument promotions (see Sec. 6.5.2.2 and 7.15.1.1 in the C99 Standard). Integer arguments undergo integer promotion and arguments of type `float` are promoted to `double`. For integer arguments, if a data type can be represented by an `int`, for instance, `char` or `short`, it is promoted to an `int`. Otherwise, it is promoted to an `unsigned int`. All other arguments do not undergo promotion.

To avoid undefined and implementation-defined behavior, minimize the use of variadic functions. Use the checkers for `MISRA C:2012 Rule 17.1` or `MISRA C++:2008 Rule 8-4-1` to detect use of variadic functions.

Example - `char` Used as Function Argument Type and `va_arg` argument

```
#include <stdarg.h>
#include <stdio.h>

unsigned char func(size_t count, ...) {
    va_list ap;
    unsigned char result = 0;
    va_start(ap, count);
    if (count > 0) {
        result = va_arg(ap, unsigned char);
    }
    va_end(ap);
    return result;
}
```

```
void func_caller(void) {
    unsigned char c = 0x12;
    (void)func(1, c);
}
```

In this example, `func` takes an `unsigned char` argument, which undergoes default argument promotion to `int`. The data type in the `va_arg` call is still `unsigned char`, which does not match the `int` argument type.

Correction — Use `int` as `va_arg` Argument

One possible correction is to read an `int` argument with `va_arg`.

```
#include <stdarg.h>
#include <stdio.h>

unsigned char func(size_t count, ...) {
    va_list ap;
    unsigned char result = 0;
    va_start(ap, count);
    if (count > 0) {
        result = va_arg(ap, int);
    }
    va_end(ap);
    return result;
}

void func_caller(void) {
    unsigned char c = 0x12;
    (void)func(1, c);
}
```

Too many va_arg calls for current argument list

Description

Too many va_arg calls for current argument list occurs when the number of calls to `va_arg` exceeds the number of arguments passed to the corresponding variadic function. The analysis raises a defect only when the variadic function is called.

Too many va_arg calls for current argument list does not raise a defect when:

- The number of calls to `va_arg` inside the variadic function is indeterminate. For example, if the calls are from an external source.
- The `va_list` used in `va_arg` is invalid.

Risk

When you call `va_arg` and there is no next argument available in `va_list`, the behavior is undefined. The call to `va_arg` might corrupt data or return an unexpected result.

Fix

Ensure that you pass the correct number of arguments to the variadic function.

Example - No Argument Available When Calling `va_arg`

```
#include <stdarg.h>
#include <stddef.h>
#include <math.h>

/* variadic function defined with
* one named argument 'count'
*/
int variadic_func(int count, ...) {
    int result = -1;
    va_list ap;
    va_start(ap, count);
    if (count > 0) {
        result = va_arg(ap, int);
        count --;
        if (count > 0) {
/* No further argument available
* in va_list when calling va_arg
*/

            result += va_arg(ap, int);
        }
    }
    va_end(ap);
    return result;
}

void func(void) {

    (void)variadic_func(2, 100);
```

```
}
```

In this example, the named argument and only one variadic argument are passed to `variadic_func()` when it is called inside `func()`. On the second call to `va_arg`, no further variadic argument is available in `ap` and the behavior is undefined.

Correction — Pass Correct Number of Arguments to Variadic Function

One possible correction is to ensure that you pass the correct number of arguments to the variadic function.

```
#include <stdarg.h>
#include <stddef.h>
#include <math.h>

/* variadic function defined with
* one named argument 'count'
*/

int variadic_func(int count, ...) {
    int result = -1;
    va_list ap;
    va_start(ap, count);
    if (count > 0) {
        result = va_arg(ap, int);
        count --;
        if (count > 0) {

/* The correct number of arguments is
* passed to va_list when variadic_func()
* is called inside func()
*/
            result += va_arg(ap, int);
        }
    }
    va_end(ap);
    return result;
}

void func(void) {

    (void)variadic_func(2, 100, 200);

}
```

Check Information

Group: 02. Expressions (EXP)

See Also

External Websites

EXP47-C

Introduced in R2019a

CERT C++: EXP50-CPP

Do not depend on the order of evaluation for side effects

Description

Rule Definition

Do not depend on the order of evaluation for side effects.

Examples

Expression value depends on order of evaluation

Description

The issue occurs when the value of an expression is not the same depending on the order of evaluation of the expression.

An expression can have different values under the following conditions:

- The same variable is modified more than once in the expression, or is both read and written.
- The expression allows more than one order of evaluation.

Therefore, the rule checker forbids expressions where a variable is modified more than once and can cause different results under different orders of evaluation. The rule checker also detects cases where a volatile variable is read more than once in an expression.

Risk

If an expression results in different values depending on the order of evaluation, its value becomes implementation-defined.

Check Information

Group: 02. Expressions (EXP)

See Also

External Websites

EXP50-CPP

Introduced in R2019a

CERT C++: EXP52-CPP

Do not rely on side effects in unevaluated operands

Description

Rule Definition

Do not rely on side effects in unevaluated operands.

Examples

Logical operator operand with side effects

Description

The issue occurs when the right hand operand of a logical && or || operator contains side effects.

The checker does not show a warning on volatile accesses and function calls.

Check Information

Group: 02. Expressions (EXP)

See Also

External Websites

EXP52-CPP

Introduced in R2019a

CERT C++: EXP53-CPP

Do not read uninitialized memory

Description

Rule Definition

Do not read uninitialized memory.

Examples

Non-initialized pointer

Description

Non-initialized pointer occurs when a pointer is not assigned an address before dereference.

Risk

Unless a pointer is explicitly assigned an address, it points to an unpredictable location.

Fix

The fix depends on the root cause of the defect. For instance, you assigned an address to the pointer but the assignment is unreachable.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below. It is a good practice to initialize a pointer to NULL when declaring the pointer.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Non-initialized pointer error

```
#include <stdlib.h>

int* assign_pointer(int* prev)
{
    int j = 42;
    int* pi;

    if (prev == NULL)
      {
        pi = (int*)malloc(sizeof(int));
        if (pi == NULL) return NULL;
      }

    *pi = j;
    /* Defect: Writing to uninitialized pointer */

    return pi;
}
```

If `prev` is not `NULL`, the pointer `pi` is not assigned an address. However, `pi` is dereferenced on every execution paths, irrespective of whether `prev` is `NULL` or not.

Correction — Initialize Pointer on Every Execution Path

One possible correction is to assign an address to `pi` when `prev` is not `NULL`.

```
#include <stdlib.h>

int* assign_pointer(int* prev)
{
    int j = 42;
    int* pi;

    if (prev == NULL)
       {
        pi = (int*)malloc(sizeof(int));
        if (pi == NULL) return NULL;
       }
    /* Fix: Initialize pi in branches of if statement  */
    else
```

```
        pi = prev;


    *pi = j;

    return pi;
}
```

Non-initialized variable

Description

Non-initialized variable occurs when a variable is not initialized before its value is read.

Risk

Unless a variable is explicitly initialized, the variable value is unpredictable. You cannot rely on the variable having a specific value.

Fix

The fix depends on the root cause of the defect. For instance, you assigned a value to the variable but the assignment is unreachable or you assigned a value to the variable in one of two branches of a conditional statement. Fix the unreachable code or missing assignment.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below. It is a good practice to initialize a variable at declaration.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Non-initialized variable error

```
int get_sensor_value(void)
{
    extern int getsensor(void);
    int command;
    int val;
```

```
    command = getsensor();
    if (command == 2)
      {
        val = getsensor();
      }

    return val;
    /* Defect: val does not have a value if command is not 2 */
}
```

If `command` is not 2, the variable `val` is unassigned. In this case, the return value of function `get_sensor_value` is undetermined.

Correction — Initialize During Declaration

One possible correction is to initialize `val` during declaration so that the initialization is not bypassed on some execution paths.

```
int get_sensor_value(void)
{
    extern int getsensor(void);
    int command;
    /* Fix: Initialize val */
    int val=0;

    command = getsensor();
    if (command == 2)
      {
        val = getsensor();
      }

    return val;
 }
```

`val` is assigned an initial value of 0. When `command` is not equal to 2, the function `get_sensor_value` returns this value.

Check Information

Group: 02. Expressions (EXP)

See Also

External Websites

EXP53-CPP

Introduced in R2019a

CERT C++: EXP54-CPP

Do not access an object outside of its lifetime

Description

Rule Definition

Do not access an object outside of its lifetime.

Examples

Non-initialized pointer

Description

Non-initialized pointer occurs when a pointer is not assigned an address before dereference.

Risk

Unless a pointer is explicitly assigned an address, it points to an unpredictable location.

Fix

The fix depends on the root cause of the defect. For instance, you assigned an address to the pointer but the assignment is unreachable.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below. It is a good practice to initialize a pointer to NULL when declaring the pointer.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Non-initialized pointer error

```
#include <stdlib.h>

int* assign_pointer(int* prev)
{
    int j = 42;
    int* pi;

    if (prev == NULL)
      {
        pi = (int*)malloc(sizeof(int));
        if (pi == NULL) return NULL;
      }

    *pi = j;
    /* Defect: Writing to uninitialized pointer */

    return pi;
}
```

If `prev` is not `NULL`, the pointer `pi` is not assigned an address. However, `pi` is dereferenced on every execution paths, irrespective of whether `prev` is `NULL` or not.

Correction — Initialize Pointer on Every Execution Path

One possible correction is to assign an address to `pi` when `prev` is not `NULL`.

```
#include <stdlib.h>

int* assign_pointer(int* prev)
{
    int j = 42;
    int* pi;

    if (prev == NULL)
       {
        pi = (int*)malloc(sizeof(int));
        if (pi == NULL) return NULL;
       }
    /* Fix: Initialize pi in branches of if statement  */
    else
```

```
        pi = prev;


    *pi = j;

    return pi;
}
```

Non-initialized variable

Description

Non-initialized variable occurs when a variable is not initialized before its value is read.

Risk

Unless a variable is explicitly initialized, the variable value is unpredictable. You cannot rely on the variable having a specific value.

Fix

The fix depends on the root cause of the defect. For instance, you assigned a value to the variable but the assignment is unreachable or you assigned a value to the variable in one of two branches of a conditional statement. Fix the unreachable code or missing assignment.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below. It is a good practice to initialize a variable at declaration.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Non-initialized variable error

```
int get_sensor_value(void)
{
    extern int getsensor(void);
    int command;
    int val;
```

```
    command = getsensor();
    if (command == 2)
      {
        val = getsensor();
      }

    return val;
    /* Defect: val does not have a value if command is not 2 */
}
```

If `command` is not 2, the variable `val` is unassigned. In this case, the return value of function `get_sensor_value` is undetermined.

Correction — Initialize During Declaration

One possible correction is to initialize `val` during declaration so that the initialization is not bypassed on some execution paths.

```
int get_sensor_value(void)
{
    extern int getsensor(void);
    int command;
    /* Fix: Initialize val */
    int val=0;

    command = getsensor();
    if (command == 2)
      {
        val = getsensor();
      }

    return val;
 }
```

`val` is assigned an initial value of 0. When `command` is not equal to 2, the function `get_sensor_value` returns this value.

Use of previously freed pointer

Description

Use of previously freed pointer occurs when you access a block of memory after freeing the block using the `free` function.

Risk

When a pointer is allocated dynamic memory with `malloc`, `calloc` or `realloc`, it points to a memory location on the heap. When you use the `free` function on this pointer, the associated block of memory is freed for reallocation. Trying to access this block of memory can result in unpredictable behavior or even a segmentation fault.

Fix

The fix depends on the root cause of the defect. See if you intended to free the memory later or allocate another memory block to the pointer before access.

As a good practice, after you free a memory block, assign the corresponding pointer to NULL. Before dereferencing pointers, check them for NULL values and handle the error. In this way, you are protected against accessing a freed block.

Example - Use of Previously Freed Pointer Error

```
#include <stdlib.h>
#include <stdio.h>
 int increment_content_of_address(int base_val, int shift)
   {
    int j;
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return 0;

    *pi = base_val;
    free(pi);

    j = *pi + shift;
    /* Defect: Reading a freed pointer */

    return j;
   }
```

The `free` statement releases the block of memory that `pi` refers to. Therefore, dereferencing`pi` after the `free` statement is not valid.

Correction — Free Pointer After Use

One possible correction is to free the pointer `pi` only after the last instance where it is accessed.

```
#include <stdlib.h>
```

```
int increment_content_of_address(int base_val, int shift)
{
    int j;
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return 0;

    *pi = base_val;

    j = *pi + shift;
    *pi = 0;

    /* Fix: The pointer is freed after its last use */
    free(pi);
    return j;
}
```

Pointer or reference to stack variable leaving scope

Description

Pointer or reference to stack variable leaving scope occurs when a pointer or reference to a local variable leaves the scope of the variable. For instance:

- A function returns a pointer to a local variable.
- A function performs the assignment `globPtr = &locVar`. `globPtr` is a global pointer variable and `locVar` is a local variable.
- A function performs the assignment `*paramPtr = &locVar`. `paramPtr` is a function parameter that is, for instance, an `int**` pointer and `locVar` is a local `int` variable.
- A C++ method performs the assignment `memPtr = &locVar`. `memPtr` is a pointer data member of the class the method belongs to. `locVar` is a variable local to the method.

The defect also applies to memory allocated using the `alloca` function. The defect does not apply to static, local variables.

Risk

Local variables are allocated an address on the stack. Once the scope of a local variable ends, this address is available for reuse. Using this address to access the local variable value outside the variable scope can cause unexpected behavior.

If a pointer to a local variable leaves the scope of the variable, Polyspace Bug Finder highlights the defect. The defect appears even if you do not use the address stored in the pointer. For maintainable code, it is a good practice to not allow the pointer to leave the variable scope. Even if you do not use the address in the pointer now, someone else using your function can use the address, causing undefined behavior.

Fix

Do not allow a pointer or reference to a local variable to leave the variable scope.

Example - Pointer to Local Variable Returned from Function

```
void func2(int *ptr) {
    *ptr = 0;
}

int* func1(void) {
    int ret = 0;
    return &ret ;
}
void main(void) {
    int* ptr = func1() ;
    func2(ptr) ;
}
```

In this example, `func1` returns a pointer to local variable `ret`.

In `main`, `ptr` points to the address of the local variable. When `ptr` is accessed in `func2`, the access is illegal because the scope of `ret` is limited to `func1`,

Accessing object with temporary lifetime

Description

Accessing object with temporary lifetime occurs when you attempt to read from or write to an object with temporary lifetime that is returned by a function call. In a structure or union returned by a function, and containing an array, the array members are temporary objects. The lifetime of temporary objects ends:

- When the full expression or full declarator containing the call ends, as defined in the C11 Standard.

- After the next sequence point, as defined in the C90 and C99 Standards. A sequence point is a point in the execution of a program where all previous evaluations are complete and no subsequent evaluation has started yet.

For C++ code, **Accessing object with temporary lifetime** raises a defect only when you write to an object with a temporary lifetime.

If the temporary lifetime object is returned by address, no defect is raised.

Risk

Modifying objects with temporary lifetime is undefined behavior and can cause abnormal program termination and portability issues.

Fix

Assign the object returned from the function call to a local variable. The content of the temporary lifetime object is copied to the variable. You can now modify it safely.

Example - Modifying Temporary Lifetime Object Returned by Function Call

```
#include <stdio.h>
#include <assert.h>
#include <stdlib.h>
#include <string.h>

#define SIZE6 6

struct S_Array
{
    int t;
    int a[SIZE6];
};

struct S_Array func_temp(void);

/* func_temp() returns a struct value containing
* an array with a temporary lifetime.
*/
int func(void) {

/*Writing to temporary lifetime object is
 undefined behavior
 */
```

```
    return ++(func_temp().a[0]);
}

void main(void) {
    (void)func();
}
```

In this example, `func_temp()` returns by value a structure with an array member `a`. This member has temporary lifetime. Incrementing it is undefined behavior.

Correction — Assign Returned Value to Local Variable Before Writing

One possible correction is to assign the return of the call to `func_temp()` to a local variable. The content of the temporary object `a` is copied to the variable, which you can safely increment.

```
 #include <stdio.h>
#include <assert.h>
#include <stdlib.h>
#include <string.h>

#define SIZE6 6

struct S_Array
{
    int t;
    int a[SIZE6];
};

struct S_Array func_temp(void);

int func(void) {

/* Assign object returned by function call to
 *local variable
 */
    struct S_Array s = func_temp();

/* Local variable can safely be
 *incremented
 */
    ++(s.a[0]);
    return s.a[0];
}
```

```
void main(void) {
    (void)func();
}
```

Check Information

Group: 02. Expressions (EXP)

See Also

External Websites

EXP54-CPP

Introduced in R2019a

CERT C++: EXP55-CPP

Do not access a cv-qualified object through a cv-unqualified type

Description

Rule Definition

Do not access a cv-qualified object through a cv-unqualified type.

Examples

Cast removes cv-qualification of pointer

Description

The issue occurs when a cast removes a `const` or `volatile` qualification from the type of a pointer or reference.

Check Information

Group: 02. Expressions (EXP)

See Also

External Websites

EXP55-CPP

Introduced in R2019a

CERT C++: EXP57-CPP

Do not cast or delete pointers to incomplete classes

Description

Rule Definition

Do not cast or delete pointers to incomplete classes.

Examples

Conversion or deletion of incomplete class pointer

Description

Conversion or deletion of incomplete class pointer occurs when you delete or cast to a pointer to an incomplete class. An incomplete class is one whose definition is not visible at the point where the class is used.

For instance, the definition of class `Body` is not visible when the `delete` operator is called on a pointer to `Body`:

```
class Handle {
  class Body *impl;
public:
  ~Handle() { delete impl; }
  // ...
};
```

Risk

When you delete a pointer to an incomplete class, it is not possible to call any nontrivial destructor that the class might have. If the destructor performs cleanup activities such as memory deallocation, these activities do not happen.

A similar problem happens, for instance, when you downcast to a pointer to an incomplete class (downcasting is casting from a pointer to a base class to a pointer to a derived class). At the point of downcasting, the relationship between the base and derived class is not known. In particular, if the derived class inherits from multiple classes, at the point of downcasting, this information is not available. The downcasting cannot make the necessary adjustments for multiple inheritance and the resulting pointer cannot be dereferenced.

A similar statement can be made for upcasting (casting from a pointer to derived class to a pointer to a base class).

Fix

When you delete or downcast to a pointer to a class, make sure that the class definition is visible.

Alternatively, you can perform one of these actions:

- Instead of a regular pointer, use the `std::shared_ptr` type to point to the incomplete class.
- When downcasting, make sure that the result is valid. Write error-handling code for invalid results.

Example - Deletion of Pointer to Incomplete Class

```
class Handle {
  class Body *impl;
public:
  ~Handle() { delete impl; }
  // ...
};
```

In this example, the definition of class `Body` is not visible when the pointer to `Body` is deleted.

Correction — Define Class Before Deletion

One possible correction is to make sure that the class definition is visible when a pointer to the class is deleted.

```
class Handle {
  class Body *impl;
public:
```

```
  ~Handle();
  // ...
};

// Elsewhere
class Body { /* ... */ };

Handle::~Handle() {
  delete impl;
}
```

Correction — Use `std::shared_ptr`

Another possible correction is to use the `std::shared_ptr` type instead of a regular pointer.

```
#include <memory>

class Handle {
  std::shared_ptr<class Body> impl;
  public:
    Handle();
    ~Handle() {}
    // ...
};
```

Example - Downcasting to Pointer to Incomplete Class

`File1.h`:

```
class Base {
protected:
  double var;
public:
  Base() : var(1.0) {}
  virtual void do_something();
  virtual ~Base();
};
```

`File2.h`:

```
void funcprint(class Derived *);
class Base *get_derived();
```

`File1.cpp`:

```
#include "File1.h"
#include "File2.h"

void getandprint() {
  Base *v = get_derived();
  funcprint(reinterpret_cast<class Derived *>(v));
}
```

`File2.cpp`:

```
#include "File2.h"
#include "File1.h"
#include <iostream>

class Base2 {
protected:
  short var2;
public:
  Base2() : var2(12) {}
};

class Derived : public Base2, public Base {
  float var_derived;
public:
    Derived() : Base2(), Base(), var_derived(1.2f) {}
    void do_something()
    {
        std::cout << "var_derived: "
                  << var_derived << ", var : " << var
                  << ", var2: " << var2 << std::endl;
    }
 };

void funcprint(Derived *d) {
  d->do_something();
}

Base *get_derived() {
  return new Derived;
}
```

In this example, the definition of class `Derived` is not visible in `File1.cpp` when a `Base*` pointer to downcast to a `Derived*` pointer.

In `File2.cpp`, class `Derived` derives from two classes, `Base` and `Base2`. This information about multiple inheritance is not available at the point of downcasting in `File1.cpp`. The result of downcasting is passed to the function `funcprint` and dereferenced in the body of `funcprint`. Because the downcasting was done with incomplete information, the dereference can be invalid.

Correction — Define Class Before Downcasting

One possible correction is to define the class `Derived` before downcasting a `Base*` pointer to a `Derived*` pointer.

In this corrected example, the downcasting is done in `File2.cpp` in the body of `funcprint` at a point where the definition of class `Derived` is visible. The downcasting is not done in `File1.cpp` where the definition of `Derived` is not visible. The changes from the previous incorrect example are highlighted.

`File1.h`:

```
class Base {
protected:
  double var;
public:
  Base() : var(1.0) {}
  virtual void do_something();
  virtual ~Base();
};
```

`File2.h`:

```
void funcprint(class Base *);
class Base *get_derived();
```

`File1.cpp`:

```
#include "File1.h"
#include "File2.h"

void getandprint() {
  Base *v = get_derived();
  funcprint(v);
}
```

`File2.cpp`:

```
#include "File2_corr.h"
#include "File1_corr.h"
#include <iostream>

class Base2 {
protected:
  short var2;
public:
  Base2() : var2(12) {}
};

class Derived : public Base2, public Base {
  float var_derived;

public:
    Derived() : Base2(), Base(), var_derived(1.2f) {}
    void do_something()
    {
        std::cout << "var_derived: "
                  << var_derived << ", var : " << var
                  << ", var2: " << var2 << std::endl;
    }
};

void funcprint(Base *d) {
  Derived *temp = dynamic_cast<Derived*>(d);
  if(temp)  {
     d->do_something();
  }
  else {
      //Handle error
  }
}

Base *get_derived() {
  return new Derived;
}
```

Check Information

Group: 02. Expressions (EXP)

See Also

External Websites

EXP57-CPP

Introduced in R2019a

CERT C++: EXP58-CPP

Pass an object of the correct type to va_start

Description

Rule Definition

Pass an object of the correct type to va_start.

Examples

Incorrect Data Types for Second Argument of `va_start`

```
#include <string>
#include <cstdarg>

double addVariableNumberOfDoubles(double* weight, short num, ...) {
    double sum=0.0;
    va_list list;
    va_start(list, num);
    for(int i=0; i < num; i++) {
        sum+=weight[i]*va_arg(list, double);
    }
    va_end(list);
    return sum;
}

double addVariableNumberOfFloats(float* weight, int num, std::string s, ...) {
    float sum=0.0;
    va_list list;
    va_start(list, s);
    for(int i=0; i < num; i++) {
        sum+=weight[i]*va_arg(list, float);
    }
    va_end(list);
    return sum;
}
```

In this example, the checker flags the call to `va_start` in:

- `addVariableNumberOfDoubles` because the argument has type `short`, which undergoes default argument promotion to `int`.
- `addVariableNumberOfFloats` because the argument has type `std::string`, which has a nontrivial copy constructor.

Correction — Fix Data Type for Second Argument of `va_start`

Make sure that the second argument of the `va_start` macro has a supported data type. In the following corrected example:

- In `addVariableNumberOfDoubles`, the data type of the last named parameter of the variadic function is changed to `int`.
- In `addVariableNumberOfFloats`, the second and third parameters of the variadic function are switched so that data type of the last named parameter is `int`.

```
#include <string>
#include <cstdarg>

double addVariableNumberOfDoubles(double* weight, int num, ...) {
    double sum=0.0;
    va_list list;
    va_start(list, num);
    for(int i=0; i < num; i++) {
        sum+=weight[i]*va_arg(list, double);
    }
    va_end(list);
    return sum;
}

double addVariableNumberOfFloats(double* weight, std::string s, int num, ...) {
    double sum=0.0;
    va_list list;
    va_start(list, num);
    for(int i=0; i < num; i++) {
        sum+=weight[i]*va_arg(list, double);
    }
    va_end(list);
    return sum;
}
```

Check Information

Group: 02. Expressions (EXP)

See Also

External Websites

EXP58-CPP

Introduced in R2019a

CERT C++: EXP59-CPP

Use offsetof() on valid types and members

Description

Rule Definition

Use offsetof() on valid types and members.

Examples

Use of `offsetof` Macro with Nonstandard Layout Class

```
#include <cstddef>

class myClass {
     int privateData;
  public:
     int publicData;
};

void func() {
  size_t off = offsetof(myClass, publicData);
  // ...
}
```

In this example, the class `myClass` has two data members with different access control, one private and the other public. Therefore, the class does not satisfy the requirements of a standard layout class and cannot be used with the `offsetof` macro.

Correction — Use Uniform Access Control for All Data Members

If the use of `offsetof` is important for the application, make sure that the first argument is a class with a standard layout. For instance, see if you can work around the need for a public data member.

```
#include <cstddef>

class myClass {
     int privateData;
     int publicData;
  public:
     int getpublicData(void) { return publicData;}
};

void func() {
  size_t off = offsetof(myClass, publicData);
  // ...
}
```

Check Information

Group: 02. Expressions (EXP)

See Also

External Websites

EXP59-CPP

Introduced in R2019a

03. Integers (INT)

CERT C++: INT30-C

Ensure that unsigned integer operations do not wrap

Description

Rule Definition

Ensure that unsigned integer operations do not wrap.

Examples

Unsigned integer overflow

Description

Unsigned integer overflow occurs when an operation on unsigned integer variables can result in values that cannot be represented by the result data type. The data type of a variable determines the number of bytes allocated for the variable storage and constrains the range of allowed values.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

The C11 standard states that unsigned integer overflows result in wrap-around behavior. However, a wrap around behavior might not always be desirable. For instance, if the result of a computation is used as an array size and the computation overflows, the array size is much smaller than expected.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If

the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

You can fix the defect by:

- Using a bigger data type for the result of the operation so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling. In the error handling code, you can override the default wrap-around behavior for overflows and implement saturation behavior, for instance.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Add One to Maximum Unsigned Integer

```
#include <limits.h>

unsigned int plusplus(void) {

    unsigned uvar = UINT_MAX;
    uvar++;
    return uvar;
}
```

In the third statement of this function, the variable `uvar` is increased by 1. However, the value of `uvar` is the maximum unsigned integer value, so 1 plus the maximum integer value cannot be represented by an `unsigned int`. The C programming language standard does not view unsigned overflow as an error because the program automatically reduces the result by modulo the maximum value plus 1. In this example, `uvar` is reduced by modulo `UINT_MAX`. The result is `uvar = 1`.

Correction — Different Storage Type

One possible correction is to store the operation result in a larger data type. In this example, by returning an `unsigned long long` instead of an `unsigned int`, the overflow error is fixed.

```
#include <limits.h>

unsigned long long plusplus(void) {
```

```
    unsigned long long ullvar = UINT_MAX;
    ullvar++;
    return ullvar;
}
```

Unsigned integer constant overflow

Description

Unsigned integer constant overflow occurs when you assign a compile-time constant to a unsigned integer variable whose data type cannot accommodate the value. An n-bit unsigned integer holds values in the range `[0, 2^n-1]`.

For instance, `c` is an 8-bit unsigned `char` variable that cannot hold the value 256.

```
unsigned char c = 256;
```

To determine the sizes of fundamental types, Bug Finder uses your specification for `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

The C standard states that overflowing unsigned integers must be wrapped around (see, for instance, the C11 standard, section 6.2.5). However, the wrap-around behavior can be unintended and cause unexpected results.

Fix

Check if the constant value is what you intended. If the value is correct, use a wider data type for the variable.

Example - Overflowing Constant from Macro Expansion

```
#define MAX_UNSIGNED_CHAR 255
#define MAX_UNSIGNED_SHORT 65535

void main() {
    unsigned char c1 = MAX_UNSIGNED_CHAR + 1;
    unsigned short c2 = MAX_UNSIGNED_SHORT + 1;
}
```

In this example, the defect appears on the macros because at least one use of the macro causes an overflow.

Correction — Use Wider Data Type

One possible correction is to use a wider data type for the variables that overflow.

```
#define MAX_UNSIGNED_CHAR 255
#define MAX_UNSIGNED_SHORT 65535

void main() {
    unsigned short c1 = MAX_UNSIGNED_CHAR + 1;
    unsigned int c2 = MAX_UNSIGNED_SHORT + 1;
}
```

Check Information

Group: 03. Integers (INT)

See Also

External Websites

INT30-C

Introduced in R2019a

CERT C++: INT31-C

Ensure that integer conversions do not result in lost or misinterpreted data

Description

Rule Definition

Ensure that integer conversions do not result in lost or misinterpreted data.

Examples

Integer conversion overflow

Description

Integer conversion overflow occurs when converting an integer to a smaller integer type. If the variable does not have enough bytes to represent the original value, the conversion overflows.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Integer conversion overflows result in undefined behavior.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variables in the overflowing computation acquire their current values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

You can fix the defect by:

- Using a bigger data type for the result of the conversion so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

In general, avoid conversions to smaller integer types.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Converting from `int` to `char`

```
char convert(void) {

    int num = 1000000;

    return (char)num;
}
```

In the return statement, the integer variable `num` is converted to a `char`. However, an 8-bit or 16-bit character cannot represent 1000000 because it requires at least 20 bits. So the conversion operation overflows.

Correction — Change Conversion Type

One possible correction is to convert to a different integer type that can represent the entire number.

```
long convert(void) {

    int num = 1000000;

    return (long)num;
}
```

Call to memset with unintended value

Description

Call to memset with unintended value occurs when Polyspace Bug Finder detects a use of the `memset` or `wmemset` function with possibly incorrect arguments.

`void *memset (void *ptr, int value, size_t num)` fills the first `num` bytes of the memory block that `ptr` points to with the specified `value`. If the argument `value` is incorrect, the memory block is initialized with an unintended value.

The unintended initialization can occur in the following cases.

Issue	Risk	Possible Fix
The second argument is `'0'` instead of `0` or `'\0'`.	The ASCII value of character `'0'` is `48` (decimal), `0x30` (hexadecimal), `069` (octal) but not `0` (or `'\0'`) .	If you want to initialize with `'0'`, use one of the ASCII values. Otherwise, use `0` or `'\0'`.
The second and third arguments are probably reversed. For instance, the third argument is a literal and the second argument is not a literal.	If the order is reversed, a memory block of unintended size is initialized with incorrect arguments.	Reverse the order of the arguments.
The second argument cannot be represented in a byte.	If the second argument cannot be represented in a byte, and you expect each byte of a memory block to be filled with that argument, the initialization does not occur as intended.	Apply a bit mask to the argument to produce a wrapped or truncated result that can be represented in a byte. When you apply a bit mask, make sure that it produces an expected result. For instance, replace `memset(a, -13, sizeof(a))` with `memset(a, (-13) & 0xFF, sizeof(a))`.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Value Cannot Be Represented in a Byte

```
#include <string.h>

#define SIZE 32
void func(void) {
    char buf[SIZE];
    int c = -2;
    memset(buf, (char)c, sizeof(buf));
}
```

In this example, `(char)c` cannot be represented in a byte.

Correction — Apply Cast

One possible correction is to apply a cast so that the result can be represented in a byte. However, check that the result of the cast is an acceptable initialization value.

```
#include <string.h>

#define SIZE 32
void func(void) {
    char buf[SIZE   ];
    int c = -2;
    memset(buf, (unsigned char)c, sizeof(buf));
}
```

Sign change integer conversion overflow

Description

Sign change integer conversion overflow occurs when converting an unsigned integer to a signed integer. If the variable does not have enough bytes to represent both the original constant and the sign bit, the conversion overflows.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Convert from `unsigned char` to `char`

```
char sign_change(void) {
    unsigned char count = 255;

    return (char)count;
}
```

In the return statement, the unsigned character variable `count` is converted to a signed character. However, `char` has 8 bits, 1 for the sign of the constant and 7 to represent the number. The conversion operation overflows because 255 uses 8 bits.

Correction — Change conversion types

One possible correction is using a larger integer type. By using an `int`, there are enough bits to represent the sign and the number value.

```
int sign_change(void) {
    unsigned char count = 255;
```

```
    return (int)count;
}
```

Tainted sign change conversion

Description

Tainted sign change conversion looks for values from unsecure sources that are converted, implicitly or explicitly, from signed to unsigned values.

For example, functions that use `size_t` as arguments implicitly convert the argument to an unsigned integer. Some functions that implicitly convert `size_t` are:

```
bcmp
memcpy
memmove
strncmp
strncpy
calloc
malloc
memalign
```

Risk

If you convert a small negative number to unsigned, the result is a large positive number. The large positive number can create security vulnerabilities. For example, if you use the unsigned value in:

- Memory size routines — causes allocating memory issues.
- String manipulation routines — causes buffer overflow.
- Loop boundaries — causes infinite loops.

Fix

To avoid converting unsigned negative values, check that the value being converted is within an acceptable range. For example, if the value represents a size, validate that the value is not negative and less than the maximum value size.

Example - Set Memory Value with Size Argument

```
#include <stdlib.h>
#include <string.h>
```

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

void bug_taintedsignchange(int size) {
    char str[SIZE128] = "";
    if (size<SIZE128) {
        memset(str, 'c', size);
    }
}
```

In this example, a `char` buffer is created and filled using `memset`. The size argument to `memset` is an input argument to the function.

The call to `memset` implicitly converts `size` to unsigned integer. If `size` is a large negative number, the absolute value could be too large to represent as an integer, causing a buffer overflow.

Correction — Check Value of `size`

One possible correction is to check if `size` is inside the valid range. This correction checks if `size` is greater than zero and less than the buffer size before calling `memset`.

```
#include <stdlib.h>
#include <string.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

void corrected_taintedsignchange(int size) {
    char str[SIZE128] = "";
    if (size>0 && size<SIZE128) {
        memset(str, 'c', size);
    }
}
```

Unsigned integer conversion overflow

Description

Unsigned integer conversion overflow occurs when converting an unsigned integer to a smaller unsigned integer type. If the variable does not have enough bytes to represent the original constant, the conversion overflows.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Integer conversion overflows result in undefined behavior.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

You can fix the defect by:

- Using a bigger data type for the result of the conversion so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

In general, avoid conversions to smaller integer types.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Converting from `int` to `char`

```
unsigned char convert(void) {
    unsigned int unum = 1000000U;
```

```
    return (unsigned char)unum;
}
```

In the return statement, the unsigned integer variable `unum` is converted to an unsigned character type. However, the conversion overflows because 1000000 requires at least 20 bits. The C programming language standard does not view unsigned overflow as an error because the program automatically reduces the result by modulo the maximum value plus 1. In this example, `unum` is reduced by modulo `2^8` because a character data type can only represent `2^8-1`.

Correction — Change Conversion Type

One possible correction is to convert to a different integer type that can represent the entire number. For example, `long`.

```
unsigned long convert(void) {
    unsigned int unum = 1000000U;

    return (unsigned long)unum;
}
```

Check Information

Group: 03. Integers (INT)

See Also

External Websites

INT31-C

Introduced in R2019a

CERT C++: INT32-C

Ensure that operations on signed integers do not result in overflow

Description

Rule Definition

Ensure that operations on signed integers do not result in overflow.

Examples

Integer overflow

Description

Integer overflow occurs when an operation on integer variables can result in values that cannot be represented by the result data type. The data type of a variable determines the number of bytes allocated for the variable storage and constrains the range of allowed values.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Integer overflows on signed integers result in undefined behavior.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variables in the overflowing computation acquire their current values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace

back using right-click options in the source code and see previous related events. See also .

You can fix the defect by:

- Using a bigger data type for the result of the operation so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

To avoid overflows in general, try one of these techniques:

- Keep integer variable values restricted to within half the range of signed integers.
- In operations that might overflow, check for conditions that can lead to the overflow and implement wrap around or saturation behavior depending on how the result of the operation is used. The result then becomes predictable and can be safely used in subsequent computations.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Addition of Maximum Integer

```
#include <limits.h>

int plusplus(void) {

    int var = INT_MAX;
    var++;
    return var;
}
```

In the third statement of this function, the variable `var` is increased by one. But the value of `var` is the maximum integer value, so an `int` cannot represent one plus the maximum integer value.

Correction — Different Storage Type

One possible correction is to change data types. Store the result of the operation in a larger data type (Note that on a 32-bit machine, `int` and `long` has the same size). In this

example, on a 32-bit machine, by returning a `long long` instead of an `int`, the overflow error is fixed.

```
#include <limits.h>

long long plusplus(void) {

    long long lvar = INT_MAX;
    lvar++;
    return lvar;
}
```

Tainted division operand

Description

Tainted division operand detects division operations where one or both of the integer operands is from an unsecure source.

Risk

- If the numerator is the minimum possible value and the denominator is `-1`, your division operation overflows because the result cannot be represented by the current variable size.
- If the denominator is zero, your division operation fails possibly causing your program to crash.

These risks can be used to execute arbitrary code. This code is usually outside the scope of a program's implicit security policy.

Fix

Before performing the division, validate the values of the operands. Check for denominators of `0` or `-1`, and numerators of the minimum integer value.

Example - Division of Function Arguments

```
extern void print_int(int);

int taintedintdivision(int usernum, int userden) {
    int r =  usernum/userden;
    print_int(r);
```

```
    return r;
}
```

This example function divides two argument variables, then prints and returns the result. The argument values are unknown and can cause division by zero or integer overflow.

Correction — Check Values

One possible correction is to check the values of the numerator and denominator before performing the division.

```
#include "limits.h"

extern void print_int(int);

int taintedintdivision(int usernum, int userden) {
    int r = 0;
    if (userden!=0 && !(usernum=INT_MIN && userden==-1)) {
        r = usernum/userden;
    }
    print_int(r);
    return r;
}
```

Tainted modulo operand

Description

Tainted modulo operand checks the operands of remainder `%` operations. Bug Finder flags modulo operations with one or more tainted operands.

Risk

- If the second remainder operand is zero, your remainder operation fails, causing your program to crash.
- If the second remainder operand is `-1`, your remainder operation can overflow if the remainder operation is implemented based on the division operation that can overflow.
- If one of the operands is negative, the operation result is uncertain. For C89, the modulo operation is not standardized, so the result from negative operands is implementation-defined.

These risks can be exploited by attackers to gain access to your program or the target in general.

Fix

Before performing the modulo operation, validate the values of the operands. Check the second operand for values of `0` and `-1`. Check both operands for negative values.

Example - Modulo with Function Arguments

```
extern void print_int(int);

int taintedintmod(int userden) {
    int rem =  128%userden;
    print_int(rem);
    return rem;
}
```

In this example, the function performs a modulo operation by using an input argument. The argument is not checked before calculating the remainder for values that can crash the program, such as 0 and -1.

Correction — Check Operand Values

One possible correction is to check the values of the operands before performing the modulo operation. In this corrected example, the modulo operation continues only if the second operand is greater than zero.

```
extern void print_int(int);

int taintedintmod(int userden) {
    int rem = 0;
    if (userden > 0) {
        rem = 128 % userden;
    }
    print_int(rem);
    return rem;
}
```

Check Information

Group: 03. Integers (INT)

See Also

External Websites

INT32-C

Introduced in R2019a

CERT C++: INT33-C

Ensure that division and remainder operations do not result in divide-by-zero errors

Description

Rule Definition

Ensure that division and remainder operations do not result in divide-by-zero errors.

Examples

Integer division by zero

Description

Integer division by zero occurs when the denominator of a division or modulo operation can be a zero-valued integer.

Risk

A division by zero can result in a program crash.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the denominator variable acquires a zero value. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

It is a good practice to check for zero values of a denominator before division and handle the error. Instead of performing the division directly:

```
res = num/den;
```

use a library function that handles zero values of the denominator before performing the division:

```
res = div(num, den);
```

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Dividing an Integer by Zero

```
int fraction(int num)
{
    int denom = 0;
    int result = 0;

    result = num/denom;

    return result;
}
```

A division by zero error occurs at `num/denom` because `denom` is zero.

Correction — Check Before Division

```
int fraction(int num)
{
    int denom = 0;
    int result = 0;

    if (denom != 0)
        result = num/denom;

    return result;
}
```

Before dividing, add a test to see if the denominator is zero, checking before division occurs. If `denom` is always zero, this correction can produce a dead code defect in your Polyspace results.

Correction — Change Denominator

One possible correction is to change the denominator value so that `denom` is not zero.

```
int fraction(int num)
{
    int denom = 2;
    int result = 0;

    result = num/denom;

    return result;
}
```

Example - Modulo Operation with Zero

```
int mod_arr(int input)
{
    int arr[5];
    for(int i = 0; i < 5; i++)
    {
        arr[i] = input % i;
    }

    return arr[0]+arr[1]+arr[2]+arr[3]+arr[4];
}
```

In this example, Polyspace flags the modulo operation as a division by zero. Because modulo is inherently a division operation, the divisor (right hand argument) cannot be zero. The modulo operation uses the `for` loop index as the divisor. However, the `for` loop starts at zero, which cannot be an iterator.

Correction — Check Divisor Before Operation

One possible correction is checking the divisor before the modulo operation. In this example, see if the index `i` is zero before the modulo operation.

```
int mod_arr(int input)
{
    int arr[5];
    for(int i = 0; i < 5; i++)
    {
        if(i != 0)
        {
             arr[i] = input % i;
        }
        else
        {
```

```
            arr[i] = input;
        }
    }

    return arr[0]+arr[1]+arr[2]+arr[3]+arr[4];
}
```

Correction — Change Divisor

Another possible correction is changing the divisor to a nonzero integer. In this example, add one to the index before the `%` operation to avoid dividing by zero.

```
int mod_arr(int input)
{
    int arr[5];
    for(int i = 0; i < 5; i++)
    {
         arr[i] = input % (i+1);
    }

    return arr[0]+arr[1]+arr[2]+arr[3]+arr[4];
}
```

Tainted division operand

Description

Tainted division operand detects division operations where one or both of the integer operands is from an unsecure source.

Risk

- If the numerator is the minimum possible value and the denominator is `-1`, your division operation overflows because the result cannot be represented by the current variable size.
- If the denominator is zero, your division operation fails possibly causing your program to crash.

These risks can be used to execute arbitrary code. This code is usually outside the scope of a program's implicit security policy.

Fix

Before performing the division, validate the values of the operands. Check for denominators of `0` or `-1`, and numerators of the minimum integer value.

Example - Division of Function Arguments

```
extern void print_int(int);

int taintedintdivision(int usernum, int userden) {
    int r =  usernum/userden;
    print_int(r);
    return r;
}
```

This example function divides two argument variables, then prints and returns the result. The argument values are unknown and can cause division by zero or integer overflow.

Correction — Check Values

One possible correction is to check the values of the numerator and denominator before performing the division.

```
#include "limits.h"

extern void print_int(int);

int taintedintdivision(int usernum, int userden) {
    int r = 0;
    if (userden!=0 && !(usernum=INT_MIN && userden==-1)) {
        r = usernum/userden;
    }
    print_int(r);
    return r;
}
```

Tainted modulo operand

Description

Tainted modulo operand checks the operands of remainder `%` operations. Bug Finder flags modulo operations with one or more tainted operands.

Risk

- If the second remainder operand is zero, your remainder operation fails, causing your program to crash.
- If the second remainder operand is `-1`, your remainder operation can overflow if the remainder operation is implemented based on the division operation that can overflow.
- If one of the operands is negative, the operation result is uncertain. For C89, the modulo operation is not standardized, so the result from negative operands is implementation-defined.

These risks can be exploited by attackers to gain access to your program or the target in general.

Fix

Before performing the modulo operation, validate the values of the operands. Check the second operand for values of `0` and `-1`. Check both operands for negative values.

Example - Modulo with Function Arguments

```
extern void print_int(int);

int taintedintmod(int userden) {
    int rem =  128%userden;
    print_int(rem);
    return rem;
}
```

In this example, the function performs a modulo operation by using an input argument. The argument is not checked before calculating the remainder for values that can crash the program, such as 0 and -1.

Correction — Check Operand Values

One possible correction is to check the values of the operands before performing the modulo operation. In this corrected example, the modulo operation continues only if the second operand is greater than zero.

```
extern void print_int(int);

int taintedintmod(int userden) {
    int rem = 0;
    if (userden > 0) {
```

```
        rem = 128 % userden;
    }
    print_int(rem);
    return rem;
}
```

Check Information

Group: 03. Integers (INT)

See Also

External Websites

INT33-C

Introduced in R2019a

CERT C++: INT34-C

Do not shift an expression by a negative number of bits or by greater than or equal to the number of bits that exist in the operand

Description

Rule Definition

Do not shift an expression by a negative number of bits or by greater than or equal to the number of bits that exist in the operand.

Examples

Shift of a negative value

Description

Shift of a negative value occurs when a bit-wise shift is used on a variable that can have negative values.

Risk

Shifts on negative values overwrite the sign bit that identifies a number as negative. The shift operation can result in unexpected values.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variable being shifted acquires negative values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

To fix the defect, check for negative values before the bit-wise shift operation and perform appropriate error handling.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Shifting a negative variable

```
int shifting(int val)
{
    int res = -1;
    return res << val;
}
```

In the return statement, the variable `res` is shifted a certain number of bits to the left. However, because `res` is negative, the shift might overwrite the sign bit.

Correction — Change the Data Type

One possible correction is to change the data type of the shifted variable to unsigned. This correction eliminates the sign bit, so left shifting does not change the sign of the variable.

```
int shifting(int val)
{
    unsigned int res = -1;
    return res << val;
}
```

Shift operation overflow

Description

Shift operation overflow occurs when a shift operation can result in values that cannot be represented by the result data type. The data type of a variable determines the number of bytes allocated for the variable storage and constrains the range of allowed values.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Shift operation overflows can result in undefined behavior.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variables in the shift operation acquire their current values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

You can fix the defect by:

- Using a bigger data type for the result of the shift operation so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Left Shift of Integer

```
int left_shift(void) {

    int foo = 33;
    return 1 << foo;
}
```

In the return statement of this function, bit-wise shift operation is performed shifting 1 `foo` bits to the left. However, an `int` has only 32 bits, so the range of the shift must be between 0 and 31. Therefore, this shift operation causes an overflow.

Correction — Different storage type

One possible correction is to store the shift operation result in a larger data type. In this example, by returning a `long long` instead of an `int`, the overflow defect is fixed.

```
long long left_shift(void) {

    int foo = 33;
    return 1LL << foo;
}
```

Check Information

Group: 03. Integers (INT)

See Also

External Websites

INT34-C

Introduced in R2019a

CERT C++: INT35-C

Use correct integer precisions

Description

Rule Definition

Use correct integer precisions.

Examples

Integer precision exceeded

Description

Integer precision exceeded occurs when an integer expression uses the integer size in an operation that exceeds the integer precision. On some architectures, the size of an integer in memory can include sign and padding bits. On these architectures, the integer size is larger than the precision which is just the number of bits that represent the value of the integer.

Risk

Using the size of an integer in an operation on the integer precision can result in integer overflow, wrap around, or unexpected results. For instance, an unsigned integer can be stored in memory in 64 bits, but uses only 48 bits to represent its value. A 56 bits left-shift operation on this integer is undefined behavior.

Assuming that the size of an integer is equal to its precision can also result in program portability issues between different architectures.

Fix

Do not use the size of an integer instead of its precision. To determine the integer precision, implement a precision computation routine or use a builtin function such as `__builtin_popcount()`.

Example - Using Size of `unsigned int` for Left Shift Operation

```
#include <limits.h>

unsigned int func(unsigned int exp)
{
    if (exp >= sizeof(unsigned int) * CHAR_BIT) {
        /* Handle error */
    }
    return 1U << exp;
}
```

In this example, the function uses a left shift operation to return the value of 2 raised to the power of `exp`. The operation shifts the bits of `1U` by `exp` positions to the left. The `if` statement ensures that the operation does not shift the bits by a number of positions `exp` greater than the size of an `unsigned int`. However, if `unsigned int` contains padding bits, the value returned by `sizeof()` is larger than the precision of `unsigned int`. As a result, some values of `exp` might be too large, and the shift operation might be undefined behavior.

Correction — Implement Function to Compute Precision of `unsigned int`

One possible correction is to implement a function `popcount()` that computes the precision of `unsigned int` by counting the number of set bits.

```
#include <stddef.h>
#include <stdint.h>
#include <limits.h>

size_t popcount(uintmax_t);
#define PRECISION(umax_value) popcount(umax_value)


unsigned int func(unsigned int exp)
{
    if (exp >= PRECISION(UINT_MAX)) {
        /* Handle error */
    }
```

```
    return 1 << exp;
}



size_t popcount(uintmax_t num)
{
    size_t precision = 0;
    while (num != 0) {
        if (num % 2 == 1) {
            precision++;
        }
        num >>= 1;
    }
    return precision;
}
```

Check Information

Group: 03. Integers (INT)

See Also

External Websites

INT35-C

Introduced in R2019a

CERT C++: INT36-C

Converting a pointer to integer or integer to pointer

Description

Rule Definition

Converting a pointer to integer or integer to pointer.

Examples

Unsafe conversion between pointer and integer

Description

Unsafe conversion between pointer and integer checks for pointer to integer and integer to pointers conversions. If you convert between a pointer, `intptr_t`, or `uintprt_t` and an integer type, such as `enum`, `ptrdiff_t`, or `pid_t`, Polyspace raises a defect.

Risk

The mapping between pointers and integers is not always consistent with the addressing structure of the environment.

Converting from pointers to integers can create:

- Truncated or out of range integer values.
- Invalid integer types.

Converting from integers to pointers can create:

- Misaligned pointers or misaligned objects.
- Invalid pointer addresses.

Fix

Where possible, avoid pointer-to-integer or integer-to-pointer conversions. If you want to convert a `void` pointer to an integer, so that you do not change the value, use types:

- C99 — `intptr_t` or `uintptr_t`
- C90 — `size_t` or `ssize_t`

Example - Integer to Pointer Conversions

```
unsigned int *badintptrcast(void)
{
    unsigned int *ptr0 = (unsigned int *)0xdeadbeef;
    char *ptr1 = (char *)0xdeadbeef;
    return (unsigned int *)(ptr0 - (unsigned int *)ptr1);
}
```

In this example, there are three conversions, two unsafe conversions and one safe conversion. The first conversion of `0xdeadbeef` to `unsigned int*` causes alignment issues for the pointer. The second conversion of `0xdeadbeef` to `char *` is safe because there are no alignment issues for `char`. The third conversion in the return casts `ptrdiff_t` to a pointer. This pointer might or might not point to an invalid address.

Correction — Use `intptr_t`

One possible correction is to use `intptr_t` types to store the pointer address `0xdeadbeef`. Also, you can change the second pointer to an integer offset so that there is no longer a conversion from `ptrdiff_t` to a pointer.

```
#include <stdint.h>

unsigned int *badintptrcast(void)
{
    intptr_t iptr0 = (intptr_t)0xdeadbeef;
    int offset = 0;
    return (unsigned int *)(iptr0 - offset);
}
```

Check Information

Group: 03. Integers (INT)

See Also

External Websites

INT36-C

Introduced in R2019a

04. Containers (CTR)

CERT C++: ARR30-C

Do not form or use out-of-bounds pointers or array subscripts

Description

Rule Definition

Do not form or use out-of-bounds pointers or array subscripts.

Examples

Array access out of bounds

Description

Array access out of bounds occurs when an array index falls outside the range `[0...array_size-1]` during array access.

Risk

Accessing an array outside its bounds is undefined behavior. You can read an unpredictable value or try to access a location that is not allowed and encounter a segmentation fault.

Fix

The fix depends on the root cause of the defect. For instance, you accessed an array inside a loop and one of these situations happened:

- The upper bound of the loop is too large.
- You used an array index that is the same as the loop index instead of being one less than the loop index.

To fix the issue, you have to modify the loop bound or the array index.

Another reason why an array index can exceed array bounds is a prior conversion from signed to unsigned integers. The conversion can result in a wrap around of the index value, eventually causing the array index to exceed the array bounds.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Array Access Out of Bounds Error

```
#include <stdio.h>

void fibonacci(void)
{
    int i;
    int fib[10];

    for (i = 0; i < 10; i++)
       {
        if (i < 2)
            fib[i] = 1;
         else
            fib[i] = fib[i-1] + fib[i-2];
       }

    printf("The 10-th Fibonacci number is %i .\n", fib[i]);
    /* Defect: Value of i is greater than allowed value of 9 */
}
```

The array `fib` is assigned a size of 10. An array index for `fib` has allowed values of `[0,1,2,...,9]`. The variable `i` has a value 10 when it comes out of the `for`-loop. Therefore, the `printf` statement attempts to access `fib[10]` through `i`.

Correction — Keep Array Index Within Array Bounds

One possible correction is to print `fib[i-1]` instead of `fib[i]` after the `for`-loop.

```
#include <stdio.h>
```

```
void fibonacci(void)
{
   int i;
   int fib[10];

   for (i = 0; i < 10; i++)
    {
        if (i < 2)
            fib[i] = 1;
        else
            fib[i] = fib[i-1] + fib[i-2];
    }

    /* Fix: Print fib[9] instead of fib[10] */
    printf("The 10-th Fibonacci number is %i .\n", fib[i-1]);
}
```

The `printf` statement accesses `fib[9]` instead of `fib[10]`.

Pointer access out of bounds

Description

Pointer access out of bounds occurs when a pointer is dereferenced outside its bounds.

When a pointer is assigned an address, a block of memory is associated with the pointer. You cannot access memory beyond that block using the pointer.

Risk

Dereferencing a pointer outside its bounds is undefined behavior. You can read an unpredictable value or try to access a location that is not allowed and encounter a segmentation fault.

Fix

The fix depends on the root cause of the defect. For instance, you dereferenced a pointer inside a loop and one of these situations happened:

- The upper bound of the loop is too large.
- You used pointer arithmetic to advance the pointer with an incorrect value for the pointer increment.

To fix the issue, you have to modify the loop bound or the pointer increment value.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Pointer access out of bounds error

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
   {
    ptr++;
    *ptr=i;
    /* Defect: ptr out of bounds for i=9 */
   }

 return(arr);
}
```

`ptr` is assigned the address `arr` that points to a memory block of size `10*sizeof(int)`. In the `for`-loop, `ptr` is incremented 10 times. In the last iteration of the loop, `ptr` points outside the memory block assigned to it. Therefore, it cannot be dereferenced.

Correction — Check Pointer Stays Within Bounds

One possible correction is to reverse the order of increment and dereference of `ptr`.

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
     {
```

```
      /* Fix: Dereference pointer before increment */
      *ptr=i;
      ptr++;
     }

 return(arr);
}
```

After the last increment, even though `ptr` points outside the memory block assigned to it, it is not dereferenced more.

Array access with tainted index

Description

Array access with tainted index detects reading or writing to an array by using a tainted index that has not been validated.

Risk

The index might be outside the valid array range. If the tainted index is outside the array range, it can cause:

- Buffer underflow/underwrite — writing to memory before the beginning of the buffer.
- Buffer overflow — writing to memory after the end of a buffer.
- Over-reading a buffer — accessing memory after the end of the targeted buffer.
- Under-reading a buffer, or accessing memory before the beginning of the targeted buffer.

An attacker can use an invalid read or write operation create to problems in your program.

Fix

Before using the index to access the array, validate the index value to make sure that it is inside the array range.

Example - Use Index to Return Buffer Value

```
#define SIZE100 100
extern int tab[SIZE100];
```

```
int taintedarrayindex(int num) {
    return tab[num];
}
```

In this example, the index `num` accesses the array `tab`. The function does not check to see if `num` is inside the range of `tab`.

Correction — Check Range Before Use

One possible correction is to check that `num` is in range before using it.

```
#define SIZE100 100
extern int tab[SIZE100];

int taintedarrayindex(int num) {
    if (num >= 0 && num < SIZE100) {
           return tab[num];
    } else {
        return -9999;
    }
}
```

Use of tainted pointer

Description

Use of tainted pointer defect is raised when:

- Tainted NULL pointer — the pointer is not validated against NULL.
- Tainted size pointer — the size of the memory zone that a pointer points to is not validated.

Note On a single pointer, your code can have instances of **Use of tainted pointer**, **Pointer dereference with tainted offset**, and **Tainted NULL or non-null-terminated string**. Bug Finder raises only the first tainted pointer defect that it finds.

Risk

An attacker can give your program a pointer that points to unexpected memory locations. If the pointer is dereferenced to write, the attacker can:

- Modify the state variables of a critical program.
- Cause your program to crash.
- Execute unwanted code.

If the pointer is dereferenced to read, the attacker can:

- Read sensitive data.
- Cause your program to crash.
- Modify a program variable to an unexpected value.

Fix

Avoid use of pointers from external sources.

Alternatively, if you trust the external source, sanitize the pointer before dereference. In a separate sanitization function:

- Check that the pointer is not NULL.
- Check the size of the memory location (if possible). This second check validates whether the size of the data the pointer points to matches the size your program expects.

The defect still appears in the body of the sanitization function. However, if you use a sanitization function, instead of several occurrences, the defect appears only once. You can justify the defect and hide it in later reviews by using code annotations. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Function That Dereferences an External Pointer

```
void taintedptr(int* p, int i) {
    *p = i;
}
```

In this example, the pointer `*p` is passed as an argument, and the value is changed. The pointer can be null or point to unknown memory, which can be vulnerable.

Correction — Avoid Use of External Pointers

One possible correction is to avoid pointers from external sources.

```
int *taintedptr(int i) {
    /* Use heap memory allocated in the application */
```

```
    int *p = (int *)malloc(sizeof (int));
    if (p != NULL) { /* Check for success */
        *p = i;
    }
return p;
}
```

Correction — Check Pointer

Another possible correction is to sanitize the pointer before using it. This example uses a second function to check if the pointer is null and can be dereferenced.

```
#include <stdlib.h>

int* sanitize_ptr(int* p) {
    int* res = NULL;
    if (p && *p) { /* Tainted pointer detected here, used as "firewall" */
        /* Pointer is not null and dereference ok */
        res = p;
    }
    return res;
}
void taintedptr(int* p, int i) {
    p = sanitize_ptr(p);
    if (p) {
        *p = i;
    }
}
```

Pointer dereference with tainted offset

Description

Pointer dereference with tainted offset detects pointer dereferencing, either reading or writing, using an offset variable from an unknown or unsecure source.

This check focuses on dynamically allocated buffers. For static buffer offsets, see `Array access with tainted index`.

Risk

The index might be outside the valid array range. If the tainted index is outside the array range, it can cause:

- Buffer underflow/underwrite, or writing to memory before the beginning of the buffer.
- Buffer overflow, or writing to memory after the end of a buffer.
- Over reading a buffer, or accessing memory after the end of the targeted buffer.
- Under-reading a buffer, or accessing memory before the beginning of the targeted buffer.

An attacker can use an invalid read or write to compromise your program.

Fix

Validate the index before you use the variable to access the pointer. Check to make sure that the variable is inside the valid range and does not overflow.

Example - Dereference Pointer Array

```
#include <stdlib.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};
extern void read_pint(int*);

int taintedptroffset(int i) {
    int* pint = (int*)calloc(SIZE10, sizeof(int));
    int c = 0;
    if(pint) {
        /* Filling array */
        read_pint(pint);
        c = pint[i];
        free(pint);
    }
    return c;
}
```

In this example, the function initializes an integer pointer `pint`. The pointer is dereferenced using the input index `i`. The value of `i` could be outside the pointer range, causing an out-of-range error.

Correction — Check Index Before Dereference

One possible correction is to validate the value of the index. If the index is inside the valid range, continue with the pointer dereferencing.

```
#include <stdlib.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};
extern void read_pint(int*);

int taintedptroffset(int i) {
    int* pint = (int*)calloc(SIZE10, sizeof(int));
    int c = 0;
    if (pint) {
        /* Filling array */
        read_pint(pint);
        if (i>0 && i<SIZE10) {
            c = pint[i];
        }
        free(pint);
    }
    return c;
}
```

Check Information

Group: 04. Containers (CTR)

See Also

External Websites

ARR30-C

Introduced in R2019a

CERT C++: ARR37-C

Do not add or subtract an integer to a pointer to a non-array object

Description

Rule Definition

Do not add or subtract an integer to a pointer to a non-array object.

Examples

Invalid assumptions about memory organization

Description

Invalid assumptions about memory organization occurs when you compute the address of a variable in the stack by adding or subtracting from the address of another non-array variable.

Risk

When you compute the address of a variable in the stack by adding or subtracting from the address of another variable, you assume a certain memory organization. If your assumption is incorrect, accessing the computed address can be invalid.

Fix

Do not perform an access that relies on assumptions about memory organization.

Example - Reliance on Memory Organization

```
void func(void) {
    int var1 = 0x00000011, var2;
    *(&var1 + 1) = 0;
}
```

In this example, the programmer relies on the assumption that `&var1 + 1` provides the address of `var2`. Therefore, an **Invalid assumptions about memory organization** appears on the + operation. In addition, a **Pointer access out of bounds** error also appears on the dereference.

Correction — Do Not Rely on Memory Organization

One possible correction is not perform direct computation on addresses to access separately declared variables.

Check Information

Group: 04. Containers (CTR)

See Also

External Websites

ARR37-C

Introduced in R2019a

CERT C++: ARR38-C

Guarantee that library functions do not form invalid pointers

Description

Rule Definition

Guarantee that library functions do not form invalid pointers.

Examples

Mismatch between data length and size

Description

Mismatch between data length and size looks for memory copying functions such as `memcpy`, `memset`, or `memmove`. If you do not control the length argument and data buffer argument properly, Bug Finder raises a defect.

Risk

If an attacker can manipulate the data buffer or length argument, the attacker can cause buffer overflow by making the actual data size smaller than the length.

This mismatch in length allows the attacker to copy memory past the data buffer to a new location. If the extra memory contains sensitive information, the attacker can now access that data.

This defect is similar to the SSL Heartbleed bug.

Fix

When copying or manipulating memory, compute the length argument directly from the data so that the sizes match.

Example - Copy Buffer of Data

```
#include <stdlib.h>
#include <string.h>

typedef struct buf_mem_st {
    char *data;
    size_t max;     /* size of buffer */
} BUF_MEM;

extern BUF_MEM beta;

int cpy_data(BUF_MEM *alpha)
{
    BUF_MEM *os = alpha;
    int num, length;

    if (alpha == 0x0) return 0;
    num = 0;

    length = *(unsigned short *)os->data;
    memcpy(&(beta.data[num]), os->data + 2, length);

    return(1);
}
```

This function copies the buffer `alpha` into a buffer `beta`. However, the `length` variable is not related to `data+2`.

Correction — Check Buffer Length

One possible correction is to check the length of your buffer against the maximum value minus 2. This check ensures that you have enough space to copy the data to the `beta` structure.

```
#include <stdlib.h>
#include <string.h>

typedef struct buf_mem_st {
    char *data;
    size_t max;     /* size of buffer */
} BUF_MEM;

extern BUF_MEM beta;
```

```
int cpy_data(BUF_MEM *alpha)
{
    BUF_MEM *os = alpha;
    int num, length;

    if (alpha == 0x0) return 0;
    num = 0;

    length = *(unsigned short *)os->data;
    if (length<(os->max -2)) {
        memcpy(&(beta.data[num]), os->data + 2, length);
    }

    return(1);

}
```

Invalid use of standard library memory routine

Description

Invalid use of standard library memory routine occurs when a memory library function is called with invalid arguments. For instance, the `memcpy` function copies to an array that cannot accommodate the number of bytes copied.

Risk

Use of a memory library function with invalid arguments can result in issues such as buffer overflow.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Invalid Use of Standard Library Memory Routine Error

```
#include <string.h>
#include <stdio.h>

char* Copy_First_Six_Letters(void)
 {
  char str1[10],str2[5];

  printf("Enter string:\n");
  scanf("%s",str1);

  memcpy(str2,str1,6);
  /* Defect: Arguments of memcpy invalid: str2 has size < 6 */

  return str2;
 }
```

The size of string `str2` is 5, but six characters of string `str1` are copied into `str2` using the `memcpy` function.

Correction — Call Function with Valid Arguments

One possible correction is to adjust the size of `str2` so that it accommodates the characters copied with the `memcpy` function.

```
#include <string.h>
#include <stdio.h>

char* Copy_First_Six_Letters(void)
 {
  /* Fix: Declare str2 with size 6 */
  char str1[10],str2[6];

  printf("Enter string:\n");
  scanf("%s",str1);

  memcpy(str2,str1,6);
  return str2;
 }
```

Possible misuse of sizeof

Description

Possible misuse of sizeof occurs when Polyspace Bug Finder detects possibly unintended results from the use of `sizeof` operator. For instance:

- You use the `sizeof` operator on an array parameter name, expecting the array size. However, the array parameter name by itself is a pointer. The `sizeof` operator returns the size of that pointer.
- You use the `sizeof` operator on an array element, expecting the array size. However, the operator returns the size of the array element.
- The size argument of certain functions such as `strncmp` or `wcsncpy` is incorrect because you used the `sizeof` operator earlier with possibly incorrect expectations. For instance:
  - In a function call `strncmp(string1, string2, num)`, `num` is obtained from an incorrect use of the `sizeof` operator on a pointer.
  - In a function call `wcsncpy(destination, source, num)`, `num` is the not the number of wide characters but a size in bytes obtained by using the `sizeof` operator. For instance, you use `wcsncpy(destination, source, sizeof(destination) - 1)` instead of `wcsncpy(destination, source, (sizeof(desintation)/sizeof(wchar_t)) - 1)`.

Risk

Incorrect use of the `sizeof` operator can cause the following issues:

- If you expect the `sizeof` operator to return array size and use the return value to constrain a loop, the number of loop runs are smaller than what you expect.
- If you use the return value of `sizeof` operator to allocate a buffer, the buffer size is smaller than what you require. Insufficient buffer can lead to resultant weaknesses such as buffer overflows.
- If you use the return value of `sizeof` operator incorrectly in a function call, the function does not behave as you expect.

Fix

Possible fixes are:

- Do not use the `sizeof` operator on an array parameter name or array element to determine array size.

  The best practice is to pass the array size as a separate function parameter and use that parameter in the function body.
- Use the `sizeof` operator carefully to determine the number argument of functions such as `strncmp` or `wcsncpy`. For instance, for wide string functions such as `wcsncpy`, use the number of wide characters as argument instead of the number of bytes.

Example - `sizeof` Used Incorrectly to Determine Array Size

```
#define MAX_SIZE 1024

void func(int a[MAX_SIZE]) {
    int i;

    for (i = 0; i < sizeof(a)/sizeof(int); i++)    {
        a[i] = i + 1;
    }
}
```

In this example, `sizeof(a)` returns the size of the pointer `a` and not the array size.

Correction — Determine Array Size in Another Way

One possible correction is to use another means to determine the array size.

```
#define MAX_SIZE 1024

void func(int a[MAX_SIZE]) {
    int i;

    for (i = 0; i < MAX_SIZE; i++)    {
        a[i] = i + 1;
    }
}
```

Buffer overflow from incorrect string format specifier

Description

Buffer overflow from incorrect string format specifier occurs when the format specifier argument for functions such as `sscanf` leads to an overflow or underflow in the memory buffer argument.

Risk

If the format specifier specifies a precision that is greater than the memory buffer size, an overflow occurs. Overflows can cause unexpected behavior such as memory corruption.

Fix

Use a format specifier that is compatible with the memory buffer size.

Example - Memory Buffer Overflow

```
#include <stdio.h>

void func (char *str[]) {
    char buf[32];
    sscanf(str[1], "%33c", buf);
}
```

In this example, `buf` can contain 32 `char` elements. Therefore, the format specifier `%33c` causes a buffer overflow.

Correction — Use Smaller Precision in Format Specifier

One possible correction is to use a smaller precision in the format specifier.

```
#include <stdio.h>

void func (char *str[]) {
    char buf[32];
    sscanf(str[1], "%32c", buf);
}
```

Invalid use of standard library string routine

Description

Invalid use of standard library string routine occurs when a string library function is called with invalid arguments.

Risk

The risk depends on the type of invalid arguments. For instance, using the `strcpy` function with a source argument larger than the destination argument can result in buffer overflows.

Fix

The fix depends on the standard library function involved in the defect. In some cases, you can constrain the function arguments before the function call. For instance, if the `strcpy` function:

```
char * strcpy(char * destination, const char* source)
```

tries to copy too many bytes into the destination argument compared to the available buffer, constrain the source argument before the call to `strcpy`. In some cases, you can use an alternative function to avoid the error. For instance, instead of `strcpy`, you can use `strncpy` to control the number of bytes copied. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Invalid Use of Standard Library String Routine Error

```
#include <string.h>
#include <stdio.h>

char* Copy_String(void)
{
 char *res;
 char gbuffer[5],text[20]="ABCDEFGHIJKL";

 res=strcpy(gbuffer,text);
 /* Error: Size of text is less than gbuffer */
```

```
  return(res);
 }
```

The string `text` is larger in size than `gbuffer`. Therefore, the function `strcpy` cannot copy `text` into `gbuffer`.

Correction — Use Valid Arguments

One possible correction is to declare the destination string `gbuffer` with equal or larger size than the source string `text`.

```
#include <string.h>
 #include <stdio.h>

 char* Copy_String(void)
 {
  char *res;
  /*Fix: gbuffer has equal or larger size than text */
  char gbuffer[20],text[20]="ABCDEFGHIJKL";

  res=strcpy(gbuffer,text);

  return(res);
 }
```

Destination buffer overflow in string manipulation

Description

Destination buffer overflow in string manipulation occurs when certain string manipulation functions write to their destination buffer argument at an offset greater than the buffer size.

For instance, when calling the function `sprintf(char* buffer, const char* format)`, you use a constant string `format` of greater size than `buffer`.

Risk

Buffer overflow can cause unexpected behavior such as memory corruption or stopping your system. Buffer overflow also introduces the risk of code injection.

Fix

One possible solution is to use alternative functions to constrain the number of characters written. For instance:

- If you use `sprintf` to write formatted data to a string, use `snprintf`, `_snprintf` or `sprintf_s` instead to enforce length control. Alternatively, use `asprintf` to automatically allocate the memory required for the destination buffer.
- If you use `vsprintf` to write formatted data from a variable argument list to a string, use `vsnprintf` or `vsprintf_s` instead to enforce length control.
- If you use `wcscpy` to copy a wide string, use `wcsncpy`, `wcslcpy`, or `wcscpy_s` instead to enforce length control.

Another possible solution is to increase the buffer size.

Example - Buffer Overflow in `sprintf` Use

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";

    sprintf(buffer, fmt_string);
}
```

In this example, `buffer` can contain 20 `char` elements but `fmt_string` has a greater size.

Correction — Use `snprintf` Instead of `sprintf`

One possible correction is to use the `snprintf` function to enforce length control.

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";

    snprintf(buffer, 20, fmt_string);
}
```

Destination buffer underflow in string manipulation

Description

Destination buffer underflow in string manipulation occurs when certain string manipulation functions write to their destination buffer argument at a negative offset from the beginning of the buffer.

For instance, for the function `sprintf(char* buffer, const char* format)`, you obtain the `buffer` from an operation `buffer = (char*)arr; ... buffer += offset;`. `arr` is an array and `offset` is a negative value.

Risk

Buffer underflow can cause unexpected behavior such as memory corruption or stopping your system. Buffer underflow also introduces the risk of code injection.

Fix

If the destination buffer argument results from pointer arithmetic, see if you are decrementing a pointer. Fix the pointer decrement by modifying either the original value before decrement or the decrement value.

Example - Buffer Underflow in `sprintf` Use

```
#include <stdio.h>
#define offset -2

void func(void) {
    char buffer[20];
    char *fmt_string ="Text";

    sprintf(&buffer[offset], fmt_string);
}
```

In this example, `&buffer[offset]` is at a negative offset from the memory allocated to `buffer`.

Correction — Change Pointer Decrementer

One possible correction is to change the value of `offset`.

```
#include <stdio.h>
#define offset 2
```

```
void func(void) {
    char buffer[20];
    char *fmt_string ="Text";

    sprintf(&buffer[offset], fmt_string);
}
```

Check Information

Group: 04. Containers (CTR)

See Also

External Websites

ARR38-C

Introduced in R2019a

CERT C++: ARR39-C

Do not add or subtract a scaled integer to a pointer

Description

Rule Definition

Do not add or subtract a scaled integer to a pointer.

Examples

Incorrect pointer scaling

Description

Incorrect pointer scaling occurs when Polyspace Bug Finder considers that you are ignoring the implicit scaling in pointer arithmetic.

For instance, the defect can occur in the following situations.

Situation	Risk	Possible Fix
You use the `sizeof` operator in arithmetic operations on a pointer.	The `sizeof` operator returns the size of a data type in number of bytes. Pointer arithmetic is already implicitly scaled by the size of the data type of the pointed variable. Therefore, the use of `sizeof` in pointer arithmetic produces unintended results.	Do not use `sizeof` operator in pointer arithmetic.

Situation	Risk	Possible Fix
You perform arithmetic operations on a pointer, and then apply a cast.	Pointer arithmetic is implicitly scaled. If you do not consider this implicit scaling, casting the result of a pointer arithmetic produces unintended results.	Apply the cast before the pointer arithmetic.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Use of `sizeof` Operator

```
void func(void) {
    int arr[5] = {1,2,3,4,5};
    int *ptr = arr;

    int value_in_position_2 = *(ptr + 2*(sizeof(int)));
}
```

In this example, the operation `2*(sizeof(int))` returns twice the size of an `int` variable in bytes. However, because pointer arithmetic is implicitly scaled, the number of bytes by which `ptr` is offset is `2*(sizeof(int))*(sizeof(int))`.

In this example, the incorrect scaling shifts `ptr` outside the bounds of the array. Therefore, a **Pointer access out of bounds** error appears on the * operation.

Correction — Remove `sizeof` Operator

One possible correction is to remove the `sizeof` operator.

```
void func(void) {
    int arr[5] = {1,2,3,4,5};
```

```
    int *ptr = arr;

    int value_in_position_2 = *(ptr + 2);
}
```

Example - Cast Following Pointer Arithmetic

```
int func(void) {
    int x = 0;
    char r = *(char *)(&x + 1);
    return r;
}
```

In this example, the operation `&x + 1` offsets `&x` by `sizeof(int)`. Following the operation, the resulting pointer points outside the allowed buffer. When you dereference the pointer, a **Pointer access out of bounds** error appears on the * operation.

Correction — Apply Cast Before Pointer Arithmetic

If you want to access the second byte of `x`, first cast `&x` to a `char*` pointer and then perform the pointer arithmetic. The resulting pointer is offset by `sizeof(char)` bytes and still points within the allowed buffer, whose size is `sizeof(int)` bytes.

```
int func(void) {
    int x = 0;
    char r = *((char *)(&x )+ 1);
    return r;
}
```

Pointer access out of bounds

Description

Pointer access out of bounds occurs when a pointer is dereferenced outside its bounds.

When a pointer is assigned an address, a block of memory is associated with the pointer. You cannot access memory beyond that block using the pointer.

Risk

Dereferencing a pointer outside its bounds is undefined behavior. You can read an unpredictable value or try to access a location that is not allowed and encounter a segmentation fault.

Fix

The fix depends on the root cause of the defect. For instance, you dereferenced a pointer inside a loop and one of these situations happened:

- The upper bound of the loop is too large.
- You used pointer arithmetic to advance the pointer with an incorrect value for the pointer increment.

To fix the issue, you have to modify the loop bound or the pointer increment value.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Pointer access out of bounds error

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
   {
    ptr++;
    *ptr=i;
    /* Defect: ptr out of bounds for i=9 */
   }

 return(arr);
}
```

`ptr` is assigned the address `arr` that points to a memory block of size `10*sizeof(int)`. In the `for`-loop, `ptr` is incremented 10 times. In the last iteration of the loop, `ptr` points outside the memory block assigned to it. Therefore, it cannot be dereferenced.

Correction — Check Pointer Stays Within Bounds

One possible correction is to reverse the order of increment and dereference of `ptr`.

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
     {
      /* Fix: Dereference pointer before increment */
      *ptr=i;
      ptr++;
     }

 return(arr);
}
```

After the last increment, even though `ptr` points outside the memory block assigned to it, it is not dereferenced more.

Possible misuse of sizeof

Description

Possible misuse of sizeof occurs when Polyspace Bug Finder detects possibly unintended results from the use of `sizeof` operator. For instance:

- You use the `sizeof` operator on an array parameter name, expecting the array size. However, the array parameter name by itself is a pointer. The `sizeof` operator returns the size of that pointer.
- You use the `sizeof` operator on an array element, expecting the array size. However, the operator returns the size of the array element.
- The size argument of certain functions such as `strncmp` or `wcsncpy` is incorrect because you used the `sizeof` operator earlier with possibly incorrect expectations. For instance:
  - In a function call `strncmp(string1, string2, num)`, `num` is obtained from an incorrect use of the `sizeof` operator on a pointer.
  - In a function call `wcsncpy(destination, source, num)`, `num` is the not the number of wide characters but a size in bytes obtained by using the `sizeof`

operator. For instance, you use `wcsncpy(destination, source, sizeof(destination) - 1)` instead of `wcsncpy(destination, source, (sizeof(desintation)/sizeof(wchar_t)) - 1)`.

Risk

Incorrect use of the `sizeof` operator can cause the following issues:

- If you expect the `sizeof` operator to return array size and use the return value to constrain a loop, the number of loop runs are smaller than what you expect.
- If you use the return value of `sizeof` operator to allocate a buffer, the buffer size is smaller than what you require. Insufficient buffer can lead to resultant weaknesses such as buffer overflows.
- If you use the return value of `sizeof` operator incorrectly in a function call, the function does not behave as you expect.

Fix

Possible fixes are:

- Do not use the `sizeof` operator on an array parameter name or array element to determine array size.

  The best practice is to pass the array size as a separate function parameter and use that parameter in the function body.
- Use the `sizeof` operator carefully to determine the number argument of functions such as `strncmp` or `wcsncpy`. For instance, for wide string functions such as `wcsncpy`, use the number of wide characters as argument instead of the number of bytes.

Example - `sizeof` Used Incorrectly to Determine Array Size

```
#define MAX_SIZE 1024

void func(int a[MAX_SIZE]) {
    int i;

    for (i = 0; i < sizeof(a)/sizeof(int); i++)    {
        a[i] = i + 1;
    }
}
```

In this example, `sizeof(a)` returns the size of the pointer `a` and not the array size.

Correction — Determine Array Size in Another Way

One possible correction is to use another means to determine the array size.

```
#define MAX_SIZE 1024

void func(int a[MAX_SIZE]) {
    int i;

    for (i = 0; i < MAX_SIZE; i++)    {
        a[i] = i + 1;
    }
}
```

Check Information

Group: 04. Containers (CTR)

See Also

External Websites

ARR39-C

Introduced in R2019a

CERT C++: CTR50-CPP

Guarantee that container indices and iterators are within the valid range

Description

Rule Definition

Guarantee that container indices and iterators are within the valid range.

Examples

Array access out of bounds

Description

Array access out of bounds occurs when an array index falls outside the range `[0...array_size-1]` during array access.

Risk

Accessing an array outside its bounds is undefined behavior. You can read an unpredictable value or try to access a location that is not allowed and encounter a segmentation fault.

Fix

The fix depends on the root cause of the defect. For instance, you accessed an array inside a loop and one of these situations happened:

- The upper bound of the loop is too large.
- You used an array index that is the same as the loop index instead of being one less than the loop index.

To fix the issue, you have to modify the loop bound or the array index.

Another reason why an array index can exceed array bounds is a prior conversion from signed to unsigned integers. The conversion can result in a wrap around of the index value, eventually causing the array index to exceed the array bounds.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Array Access Out of Bounds Error

```
#include <stdio.h>

void fibonacci(void)
{
    int i;
    int fib[10];

    for (i = 0; i < 10; i++)
       {
        if (i < 2)
            fib[i] = 1;
         else
            fib[i] = fib[i-1] + fib[i-2];
       }

    printf("The 10-th Fibonacci number is %i .\n", fib[i]);
    /* Defect: Value of i is greater than allowed value of 9 */
}
```

The array `fib` is assigned a size of 10. An array index for `fib` has allowed values of `[0,1,2,...,9]`. The variable `i` has a value 10 when it comes out of the `for`-loop. Therefore, the `printf` statement attempts to access `fib[10]` through `i`.

Correction — Keep Array Index Within Array Bounds

One possible correction is to print `fib[i-1]` instead of `fib[i]` after the `for`-loop.

```
#include <stdio.h>
```

```
void fibonacci(void)
{
   int i;
   int fib[10];

   for (i = 0; i < 10; i++)
    {
        if (i < 2)
            fib[i] = 1;
        else
            fib[i] = fib[i-1] + fib[i-2];
    }

    /* Fix: Print fib[9] instead of fib[10] */
    printf("The 10-th Fibonacci number is %i .\n", fib[i-1]);
}
```

The `printf` statement accesses `fib[9]` instead of `fib[10]`.

Array access with tainted index

Description

Array access with tainted index detects reading or writing to an array by using a tainted index that has not been validated.

Risk

The index might be outside the valid array range. If the tainted index is outside the array range, it can cause:

- Buffer underflow/underwrite — writing to memory before the beginning of the buffer.
- Buffer overflow — writing to memory after the end of a buffer.
- Over-reading a buffer — accessing memory after the end of the targeted buffer.
- Under-reading a buffer, or accessing memory before the beginning of the targeted buffer.

An attacker can use an invalid read or write operation create to problems in your program.

Fix

Before using the index to access the array, validate the index value to make sure that it is inside the array range.

Example - Use Index to Return Buffer Value

```
#define SIZE100 100
extern int tab[SIZE100];

int taintedarrayindex(int num) {
    return tab[num];
}
```

In this example, the index `num` accesses the array `tab`. The function does not check to see if `num` is inside the range of `tab`.

Correction — Check Range Before Use

One possible correction is to check that `num` is in range before using it.

```
#define SIZE100 100
extern int tab[SIZE100];

int taintedarrayindex(int num) {
    if (num >= 0 && num < SIZE100) {
           return tab[num];
    } else {
        return -9999;
    }
}
```

Pointer dereference with tainted offset

Description

Pointer dereference with tainted offset detects pointer dereferencing, either reading or writing, using an offset variable from an unknown or unsecure source.

This check focuses on dynamically allocated buffers. For static buffer offsets, see `Array access with tainted index`.

Risk

The index might be outside the valid array range. If the tainted index is outside the array range, it can cause:

- Buffer underflow/underwrite, or writing to memory before the beginning of the buffer.
- Buffer overflow, or writing to memory after the end of a buffer.
- Over reading a buffer, or accessing memory after the end of the targeted buffer.
- Under-reading a buffer, or accessing memory before the beginning of the targeted buffer.

An attacker can use an invalid read or write to compromise your program.

Fix

Validate the index before you use the variable to access the pointer. Check to make sure that the variable is inside the valid range and does not overflow.

Example - Dereference Pointer Array

```
#include <stdlib.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};
extern void read_pint(int*);

int taintedptroffset(int i) {
    int* pint = (int*)calloc(SIZE10, sizeof(int));
    int c = 0;
    if(pint) {
        /* Filling array */
        read_pint(pint);
        c = pint[i];
        free(pint);
    }
    return c;
}
```

In this example, the function initializes an integer pointer `pint`. The pointer is dereferenced using the input index `i`. The value of `i` could be outside the pointer range, causing an out-of-range error.

Correction — Check Index Before Dereference

One possible correction is to validate the value of the index. If the index is inside the valid range, continue with the pointer dereferencing.

```
#include <stdlib.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};
extern void read_pint(int*);

int taintedptroffset(int i) {
    int* pint = (int*)calloc(SIZE10, sizeof(int));
    int c = 0;
    if (pint) {
        /* Filling array */
        read_pint(pint);
        if (i>0 && i<SIZE10) {
            c = pint[i];
        }
        free(pint);
    }
    return c;
}
```

Check Information

Group: 04. Containers (CTR)

See Also

External Websites

CTR50-CPP

Introduced in R2019a

05. Characters and Strings (STR)

CERT C++: STR30-C

Do not attempt to modify string literals

Description

Rule Definition

Do not attempt to modify string literals.

Examples

Writing to const qualified object

Description

Writing to `const` qualified object occurs when you do one of the following:

- Use a `const`-qualified object as the destination of an assignment.
- Pass a `const`-qualified object to a function that modifies the argument.

For instance, the defect can occur in the following situations:

- You pass a `const`-qualified object as first argument of one of the following functions:
  - `mkstemp`
  - `mkostemp`
  - `mkostemps`
  - `mkdtemp`
- You pass a `const`-qualified object as the destination argument of one of the following functions:
  - `strcpy`
  - `strncpy`

  - `strcat`
  - `memset`
- You perform a write operation on a `const`-qualified object.

Risk

The risk depends upon the modifications made to the `const`-qualified object.

Situation	Risk
Passing to `mkstemp`, `mkostemp`, `mkostemps`, `mkdtemp`, and so on.	These functions replace the last six characters of their first argument with a string. Therefore, they expect a modifiable `char` array as their first argument.
Passing to `strcpy`, `strncpy`, `strcat`, `memset` and so on.	These functions modify their destination argument. Therefore, they expect a modifiable `char` array as their destination argument.
Writing to the object	The `const` qualifier implies an agreement that the value of the object will not be modified. By writing to a `const`-qualified object, you break the agreement. The result of the operation is undefined.

Fix

The fix depends on the modification made to the `const`-qualified object.

Situation	Fix
Passing to `mkstemp`, `mkostemp`, `mkostemps`, `mkdtemp`, and so on.	Pass a non-`const` object as first argument of the function.
Passing to `strcpy`, `strncpy`, `strcat`, `memset` and so on.	Pass a non-`const` object as destination argument of the function.
Writing to the object	Perform the write operation on a non-`const` object.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Writing to `const`-Qualified Object

```
#include <string.h>

const char* buffer = "abcdeXXXXXXX";

void func(char* string) {
    char *ptr = (char*)strchr(buffer,'X');
    if(ptr)
        strcpy(ptr,string);
}
```

In this example, because `buffer` is `const`-qualified, `strchr(buffer,'X')` returns a `const`-qualified `char*` pointer. When this `char*` pointer is used as the destination argument of `strcpy`, a **Writing to const qualified object** error appears.

Correction — Copy `const`-Qualified Object to Non-`const` Object

One possible correction is to assign the constant string to a non-`const` object and use the non-`const` object as destination argument of `strchr`.

```
#include <string.h>

char buffer[] = "abcdeXXXXXXX";

void func(char* string) {
    char *ptr = (char*)strchr(buffer,'X');
    if(ptr)
        strcpy(ptr,string);
}
```

Check Information

Group: 05. Characters and Strings (STR)

See Also

External Websites

STR30-C

Introduced in R2019a

CERT C++: STR31-C

Guarantee that storage for strings has sufficient space for character data and the null terminator

Description

Rule Definition

Guarantee that storage for strings has sufficient space for character data and the null terminator.

Examples

Use of dangerous standard function

Description

The **Use of dangerous standard function** check highlights uses of functions that are inherently dangerous or potentially dangerous given certain circumstances. The following table lists possibly dangerous functions, the risks of using each function, and what function to use instead.

Dangerous Function	Risk Level	Safer Function
`gets`	Inherently dangerous — You cannot control the length of input from the console.	`fgets`
`cin`	Inherently dangerous — You cannot control the length of input from the console.	Avoid or prefaces calls to `cin` with `cin.width`.

Dangerous Function	Risk Level	Safer Function
`strcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`strncpy`
`stpcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`stpncpy`
`lstrcpy` or `StrCpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`StringCbCopy`, `StringCchCopy`, `strncpy`, `strcpy_s`, or `strlcpy`
`strcat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`strncat`, `strlcat`, or `strcat_s`
`lstrcat` or `StrCat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`StringCbCat`, `StringCchCat`, `strncay`, `strcat_s`, or `strlcat`
`wcpcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`wcpncpy`
`wcscat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`wcsncat`, `wcslcat`, or `wcncat_s`
`wcscpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`wcsncpy`

Dangerous Function	Risk Level	Safer Function
`sprintf`	Possibly dangerous — If the output length depends on unknown lengths or values, buffer overflow can occur.	`snprintf`
`vsprintf`	Possibly dangerous — If the output length depends on unknown lengths or values, buffer overflow can occur.	`vsnprintf`

Risk

These functions can cause buffer overflow, which attackers can use to infiltrate your program.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Using `sprintf`

```
#include <stdio.h>
#include <string.h>
#include <iostream>

#define BUFF_SIZE 128


int dangerous_func(char *str)
{
    char dst[BUFF_SIZE];
    int r = 0;
```

```
    if (sprintf(dst, "%s", str) == 1)
    {
        r += 1;
        dst[BUFF_SIZE-1] = '\0';
    }

    return r;
}
```

This example function uses `sprintf` to copy the string `str` to `dst`. However, if `str` is larger than the buffer, `sprintf` can cause buffer overflow.

Correction — Use `snprintf` with Buffer Size

One possible correction is to use `snprintf` instead and specify a buffer size.

```
#include <stdio.h>
#include <string.h>
#include <iostream>

#define BUFF_SIZE 128


int dangerous_func(char *str)
{
    char dst[BUFF_SIZE];
    int r = 0;

    if (snprintf(dst, sizeof(dst), "%s", str) == 1)
    {
        r += 1;
        dst[BUFF_SIZE-1] = '\0';
    }

    return r;
}
```

Missing null in string array

Description

Missing null in string array occurs when a string does not have enough space to terminate with a null character `'\0'`.

This defect applies only for projects in C.

Risk

A buffer overflow can occur if you copy a string to an array without assuming the implicit null terminator.

Fix

If you initialize a character array with a literal, avoid specifying the array bounds.

```
char three[]  = "THREE";
```

The compiler automatically allocates space for a null terminator. In the preceding example, the compiler allocates sufficient space for five characters and a null terminator.

If the issue occurs after initialization, you might have to increase the size of the array by one to account for the null terminator.

In certain circumstances, you might want to initialize the character array with a sequence of characters instead of a string. In this situation, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Array size is too small

```
void countdown(int i)
{
    static char one[5]   = "ONE";
    static char two[5]   = "TWO";
    static char three[5] = "THREE";
}
```

The character array `three` has a size of 5 and 5 characters `'T'`, `'H'`, `'R'`, `'E'`, and `'E'`. There is no room for the null character at the end because `three` is only five bytes large.

Correction — Increase Array Size

One possible correction is to change the array size to allow for the five characters plus a null character.

```
void countdown(int i)
{
    static char one[5]   = "ONE";
    static char two[5]   = "TWO";
```

```
    static char three[6] = "THREE";
}
```

Correction — Change Initialization Method

One possible correction is to initialize the string by leaving the array size blank. This initialization method allocates enough memory for the five characters and a terminating-null character.

```
void countdown(int i)
{
    static char one[5]   = "ONE";
    static char two[5]   = "TWO";
    static char three[]  = "THREE";
}
```

Buffer overflow from incorrect string format specifier

Description

Buffer overflow from incorrect string format specifier occurs when the format specifier argument for functions such as `sscanf` leads to an overflow or underflow in the memory buffer argument.

Risk

If the format specifier specifies a precision that is greater than the memory buffer size, an overflow occurs. Overflows can cause unexpected behavior such as memory corruption.

Fix

Use a format specifier that is compatible with the memory buffer size.

Example - Memory Buffer Overflow

```
#include <stdio.h>

void func (char *str[]) {
    char buf[32];
    sscanf(str[1], "%33c", buf);
}
```

In this example, `buf` can contain 32 `char` elements. Therefore, the format specifier `%33c` causes a buffer overflow.

Correction — Use Smaller Precision in Format Specifier

One possible correction is to use a smaller precision in the format specifier.

```
#include <stdio.h>

void func (char *str[]) {
    char buf[32];
    sscanf(str[1], "%32c", buf);
}
```

Destination buffer overflow in string manipulation

Description

Destination buffer overflow in string manipulation occurs when certain string manipulation functions write to their destination buffer argument at an offset greater than the buffer size.

For instance, when calling the function `sprintf(char* buffer, const char* format)`, you use a constant string `format` of greater size than `buffer`.

Risk

Buffer overflow can cause unexpected behavior such as memory corruption or stopping your system. Buffer overflow also introduces the risk of code injection.

Fix

One possible solution is to use alternative functions to constrain the number of characters written. For instance:

- If you use `sprintf` to write formatted data to a string, use `snprintf`, `_snprintf` or `sprintf_s` instead to enforce length control. Alternatively, use `asprintf` to automatically allocate the memory required for the destination buffer.
- If you use `vsprintf` to write formatted data from a variable argument list to a string, use `vsnprintf` or `vsprintf_s` instead to enforce length control.
- If you use `wcscpy` to copy a wide string, use `wcsncpy`, `wcslcpy`, or `wcscpy_s` instead to enforce length control.

Another possible solution is to increase the buffer size.

Example - Buffer Overflow in `sprintf` Use

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";

    sprintf(buffer, fmt_string);
}
```

In this example, `buffer` can contain 20 `char` elements but `fmt_string` has a greater size.

Correction — Use `snprintf` Instead of `sprintf`

One possible correction is to use the `snprintf` function to enforce length control.

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";

    snprintf(buffer, 20, fmt_string);
}
```

Tainted NULL or non-null-terminated string

Description

Tainted NULL or non-null-terminated string looks for strings from unsecure sources that are being used in string manipulation routines that implicitly dereference the string buffer. For example, `strcpy` or `sprintf`.

Tainted NULL or non-null-terminated string raises no defect for a string returned from a call to `scanf`-family variadic functions. Similarly, no defect is raised when you pass the string with a `%s` specifier to `printf`-family variadic functions.

Note If you reference a string using the form `ptr[i]`, `*ptr`, or pointer arithmetic, Bug Finder raises a **Use of tainted pointer** defect instead. The **Tainted NULL or non-null-terminated string** defect is raised only when the pointer is used as a string.

Risk

If a string is from an unsecure source, it is possible that an attacker manipulated the string or pointed the string pointer to a different memory location.

If the string is NULL, the string routine cannot dereference the string, causing the program to crash. If the string is not null-terminated, the string routine might not know when the string ends. This error can cause you to write out of bounds, causing a buffer overflow.

Fix

Validate the string before you use it. Check that:

- The string is not NULL.
- The string is null-terminated
- The size of the string matches the expected size.

Example - Getting String from Input Argument

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128

extern void print_str(const char*);

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}
```

In this example, the string `str` is concatenated with the argument `userstr`. The value of `userstr` is unknown. If the size of `userstr` is greater than the space available, the concatenation overflows.

Correction — Validate the Data

One possible correction is to check the size of `userstr` and make sure that the string is null-terminated before using it in `strncat`. This example uses a helper function, `sansitize_str`, to validate the string. The defects are concentrated in this function.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128

extern void print_str(const char*);

int sanitize_str(char* s) {
  int res = 0;
  if (s && (strlen(s) > 0)) { // TAINTED_STRING only flagged here
    // - string is not null
    // - string has a positive and limited size
    // - TAINTED_STRING on strlen used as a firewall
    res = 1;
  }
  return res;
}

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    if (sanitize_str(userstr))
      strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  if (sanitize_str(userstr))
    strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}
```

Correction — Validate the Data

Another possible correction is to call function `errorMsg` and `warningMsg` with specific strings.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128

extern void print_str(const char*);

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}

int manageSensorValue(int sensorValue) {
  int ret = sensorValue;
  if ( sensorValue < 0 ) {
    errorMsg("sensor value should be positive");
    exit(1);
  } else if ( sensorValue > 50 ) {
    warningMsg("sensor value greater than 50 (applying threshold)...");
    sensorValue = 50;
  }

  return sensorValue;
}
```

Check Information

Group: 05. Characters and Strings (STR)

See Also

External Websites

STR31-C

Introduced in R2019a

CERT C++: STR32-C

Do not pass a non-null-terminated character sequence to a library function that expects a string

Description

Rule Definition

Do not pass a non-null-terminated character sequence to a library function that expects a string.

Examples

Invalid use of standard library string routine

Description

Invalid use of standard library string routine occurs when a string library function is called with invalid arguments.

Risk

The risk depends on the type of invalid arguments. For instance, using the `strcpy` function with a source argument larger than the destination argument can result in buffer overflows.

Fix

The fix depends on the standard library function involved in the defect. In some cases, you can constrain the function arguments before the function call. For instance, if the `strcpy` function:

```
char * strcpy(char * destination, const char* source)
```

tries to copy too many bytes into the destination argument compared to the available buffer, constrain the source argument before the call to `strcpy`. In some cases, you can

use an alternative function to avoid the error. For instance, instead of `strcpy`, you can use `strncpy` to control the number of bytes copied. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Invalid Use of Standard Library String Routine Error

```
#include <string.h>
#include <stdio.h>

char* Copy_String(void)
{
 char *res;
 char gbuffer[5],text[20]="ABCDEFGHIJKL";

 res=strcpy(gbuffer,text);
 /* Error: Size of text is less than gbuffer */

 return(res);
}
```

The string `text` is larger in size than `gbuffer`. Therefore, the function `strcpy` cannot copy `text` into `gbuffer`.

Correction — Use Valid Arguments

One possible correction is to declare the destination string `gbuffer` with equal or larger size than the source string `text`.

```
#include <string.h>
#include <stdio.h>

char* Copy_String(void)
{
 char *res;
 /*Fix: gbuffer has equal or larger size than text */
 char gbuffer[20],text[20]="ABCDEFGHIJKL";

 res=strcpy(gbuffer,text);

 return(res);
}
```

Tainted NULL or non-null-terminated string

Description

Tainted NULL or non-null-terminated string looks for strings from unsecure sources that are being used in string manipulation routines that implicitly dereference the string buffer. For example, `strcpy` or `sprintf`.

Tainted NULL or non-null-terminated string raises no defect for a string returned from a call to `scanf`-family variadic functions. Similarly, no defect is raised when you pass the string with a `%s` specifier to `printf`-family variadic functions.

Note If you reference a string using the form `ptr[i]`, `*ptr`, or pointer arithmetic, Bug Finder raises a **Use of tainted pointer** defect instead. The **Tainted NULL or non-null-terminated string** defect is raised only when the pointer is used as a string.

Risk

If a string is from an unsecure source, it is possible that an attacker manipulated the string or pointed the string pointer to a different memory location.

If the string is NULL, the string routine cannot dereference the string, causing the program to crash. If the string is not null-terminated, the string routine might not know when the string ends. This error can cause you to write out of bounds, causing a buffer overflow.

Fix

Validate the string before you use it. Check that:

- The string is not NULL.
- The string is null-terminated
- The size of the string matches the expected size.

Example - Getting String from Input Argument

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
```

```
#define SIZE128 128

extern void print_str(const char*);

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}
```

In this example, the string `str` is concatenated with the argument `userstr`. The value of `userstr` is unknown. If the size of `userstr` is greater than the space available, the concatenation overflows.

Correction — Validate the Data

One possible correction is to check the size of `userstr` and make sure that the string is null-terminated before using it in `strncat`. This example uses a helper function, `sansitize_str`, to validate the string. The defects are concentrated in this function.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128

extern void print_str(const char*);

int sanitize_str(char* s) {
  int res = 0;
  if (s && (strlen(s) > 0)) { // TAINTED_STRING only flagged here
    // - string is not null
    // - string has a positive and limited size
    // - TAINTED_STRING on strlen used as a firewall
    res = 1;
  }
```

```
  return res;
}

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    if (sanitize_str(userstr))
      strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  if (sanitize_str(userstr))
    strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}
```

Correction — Validate the Data

Another possible correction is to call function `errorMsg` and `warningMsg` with specific strings.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128

extern void print_str(const char*);

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}
```

```
int manageSensorValue(int sensorValue) {
  int ret = sensorValue;
  if ( sensorValue < 0 ) {
    errorMsg("sensor value should be positive");
    exit(1);
  } else if ( sensorValue > 50 ) {
    warningMsg("sensor value greater than 50 (applying threshold)...");
    sensorValue = 50;
  }

  return sensorValue;
}
```

Check Information

Group: 05. Characters and Strings (STR)

See Also

External Websites

STR32-C

Introduced in R2019a

CERT C++: STR34-C

Cast characters to unsigned char before converting to larger integer sizes

Description

Rule Definition

Cast characters to unsigned char before converting to larger integer sizes.

Examples

Misuse of sign-extended character value

Description

Misuse of sign-extended character value occurs when you convert a signed or plain `char` data type to a wider integer data type with sign extension. You then use the resulting sign-extended value as array index, for comparison with EOF or as argument to a character-handling function.

Risk

Comparison with EOF: Suppose, your compiler implements the plain `char` type as signed. In this implementation, the character with the decimal form of 255 (–1 in two's complement form) is stored as a signed value. When you convert a `char` variable to the wider data type `int` for instance, the sign bit is preserved (sign extension). This sign extension results in the character with the decimal form 255 being converted to the integer –1, which cannot be distinguished from EOF.

Use as array index: By similar reasoning, you cannot use sign-extended plain `char` variables as array index. If the sign bit is preserved, the conversion from `char` to `int` can result in negative integers. You must use positive integer values for array index.

Argument to character-handling function: By similar reasoning, you cannot use sign-extended plain `char` variables as arguments to character-handling functions declared in

`ctype.h`, for instance, `isalpha()` or `isdigit()`. According to the C11 standard (Section 7.4), if you supply an integer argument that cannot be represented as `unsigned char` or EOF, the resulting behavior is undefined.

Fix

Before conversion to a wider integer data type, cast the signed or plain `char` value explicitly to `unsigned char`.

Example - Sign-Extended Character Value Compared with EOF

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

extern char parsed_token_buffer[20];

static int parser(char *buf)
{
    int c = EOF;
    if (buf && *buf) {
        c = *buf++;
    }
    return c;
}

void func()
{
    if (parser(parsed_token_buffer) == EOF) {
        /* Handle error */
        fatal_error();
    }
}
```

In this example, the function `parser` can traverse a string input `buf`. If a character in the string has the decimal form 255, when converted to the `int` variable `c`, its value becomes –1, which is indistinguishable from `EOF`. The later comparison with `EOF` can lead to a false positive.

Correction — Cast to `unsigned char` Before Conversion

One possible correction is to cast the plain `char` value to `unsigned char` before conversion to the wider `int` type.

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

extern char parsed_token_buffer[20];

static int parser(char *buf)
{
    int c = EOF;
    if (buf && *buf) {
        c = (unsigned char)*buf++;
    }
    return c;
}

void func()
{
    if (parser(parsed_token_buffer) == EOF) {
        /* Handle error */
        fatal_error();
    }
}
```

Check Information

Group: 05. Characters and Strings (STR)

See Also

External Websites

STR34-C

Introduced in R2019a

CERT C++: STR37-C

Arguments to character-handling functions must be representable as an unsigned char

Description

Rule Definition

Arguments to character-handling functions must be representable as an unsigned char.

Examples

Invalid use of standard library integer routine

Description

Invalid use of standard library integer routine occurs when you use invalid arguments with an integer function from the standard library. This defect picks up:

- Character Conversion

  `toupper, tolower`
- Character Checks

  `isalnum, isalpha, iscntrl, isdigit, isgraph, islower, isprint, ispunct, isspace, isupper, isxdigit`
- Integer Division

  `div, ldiv`
- Absolute Values

  `abs, labs`

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If

the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Absolute Value of Large Negative

```
#include <limits.h>
#include <stdlib.h>

int absoluteValue(void) {

    int neg = INT_MIN;
    return abs(neg);
}
```

The input value to `abs` is `INT_MIN`. The absolute value of `INT_MIN` is `INT_MAX+1`. This number cannot be represented by the type `int`.

Correction — Change Input Argument

One possible correction is to change the input value to fit returned data type. In this example, change the input value to `INT_MIN+1`.

```
#include <limits.h>
#include <stdlib.h>

int absoluteValue(void) {

    int neg = INT_MIN+1;
    return abs(neg);
}
```

Check Information

Group: 05. Characters and Strings (STR)

See Also

External Websites

STR37-C

Introduced in R2019a

CERT C++: STR38-C

Do not confuse narrow and wide character strings and functions

Description

Rule Definition

Do not confuse narrow and wide character strings and functions.

Examples

Misuse of narrow or wide character string

Description

Misuse of narrow or wide character string occurs when you pass a narrow character string to a wide string function, or a wide character string to a narrow string function.

Misuse of narrow or wide character string raises no defect on operating systems where narrow and wide character strings have the same size.

Risk

Using a narrow character string with a wide string function, or vice versa, can result in unexpected or undefined behavior.

If you pass a wide character string to a narrow string function, you can encounter these issues:

- Data truncation. If the string contains null bytes, a copy operation using `strncpy()` can terminate early.
- Incorrect string length. `strlen()` returns the number of characters of a string up to the first null byte. A wide string can have additional characters after its first null byte.

If you pass a narrow character string to a wide string function, you can encounter this issue:

- Buffer overflow. In a copy operation using `wcsncpy()`, the destination string might have insufficient memory to store the result of the copy.

Fix

Use the narrow string functions with narrow character strings. Use the wide string functions with wide character strings.

Example - Passing Wide Character Strings to `strncpy()`

```
#include <string.h>
#include <wchar.h>

void func(void)
{
    wchar_t wide_str1[]  = L"0123456789";
    wchar_t wide_str2[] =  L"0000000000";
    strncpy(wide_str2, wide_str1, 10);
}
```

In this example, `strncpy()` copies 10 wide characters from `wide_strt1` to `wide_str2`. If `wide_str1` contains null bytes, the copy operation can end prematurely and truncate the wide character string.

Correction — Use `wcsncpy()` to Copy Wide Character Strings

One possible correction is to use `wcsncpy()` to copy `wide_str1` to `wide_str2`.

```
#include <string.h>
#include <wchar.h>

void func(void)
{
    wchar_t wide_str1[]  = L"0123456789";
    wchar_t wide_str2[] =  L"0000000000";
    wcsncpy(wide_str2, wide_str1, 10);
}
```

Check Information

Group: 05. Characters and Strings (STR)

See Also

External Websites

STR38-C

Introduced in R2019a

CERT C++: STR50-CPP

Guarantee that storage for strings has sufficient space for character data and the null terminator

Description

Rule Definition

Guarantee that storage for strings has sufficient space for character data and the null terminator.

Examples

Use of dangerous standard function

Description

The **Use of dangerous standard function** check highlights uses of functions that are inherently dangerous or potentially dangerous given certain circumstances. The following table lists possibly dangerous functions, the risks of using each function, and what function to use instead.

Dangerous Function	Risk Level	Safer Function
`gets`	Inherently dangerous — You cannot control the length of input from the console.	`fgets`
`cin`	Inherently dangerous — You cannot control the length of input from the console.	Avoid or prefaces calls to `cin` with `cin.width`.

Dangerous Function	Risk Level	Safer Function
`strcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`strncpy`
`stpcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`stpncpy`
`lstrcpy` or `StrCpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`StringCbCopy`, `StringCchCopy`, `strncpy`, `strcpy_s`, or `strlcpy`
`strcat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`strncat`, `strlcat`, or `strcat_s`
`lstrcat` or `StrCat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`StringCbCat`, `StringCchCat`, `strncay`, `strcat_s`, or `strlcat`
`wcpcpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`wcpncpy`
`wcscat`	Possibly dangerous — If the concatenated result is greater than the destination, buffer overflow can occur.	`wcsncat`, `wcslcat`, or `wcncat_s`
`wcscpy`	Possibly dangerous — If the source length is greater than the destination, buffer overflow can occur.	`wcsncpy`

Dangerous Function	Risk Level	Safer Function
`sprintf`	Possibly dangerous — If the output length depends on unknown lengths or values, buffer overflow can occur.	`snprintf`
`vsprintf`	Possibly dangerous — If the output length depends on unknown lengths or values, buffer overflow can occur.	`vsnprintf`

Risk

These functions can cause buffer overflow, which attackers can use to infiltrate your program.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Using `sprintf`

```
#include <stdio.h>
#include <string.h>
#include <iostream>

#define BUFF_SIZE 128


int dangerous_func(char *str)
{
    char dst[BUFF_SIZE];
    int r = 0;
```

```
    if (sprintf(dst, "%s", str) == 1)
    {
        r += 1;
        dst[BUFF_SIZE-1] = '\0';
    }

    return r;
}
```

This example function uses `sprintf` to copy the string `str` to `dst`. However, if `str` is larger than the buffer, `sprintf` can cause buffer overflow.

Correction — Use `snprintf` with Buffer Size

One possible correction is to use `snprintf` instead and specify a buffer size.

```
#include <stdio.h>
#include <string.h>
#include <iostream>

#define BUFF_SIZE 128


int dangerous_func(char *str)
{
    char dst[BUFF_SIZE];
    int r = 0;

    if (snprintf(dst, sizeof(dst), "%s", str) == 1)
    {
        r += 1;
        dst[BUFF_SIZE-1] = '\0';
    }

    return r;
}
```

Missing null in string array

Description

Missing null in string array occurs when a string does not have enough space to terminate with a null character `'\0'`.

This defect applies only for projects in C.

Risk

A buffer overflow can occur if you copy a string to an array without assuming the implicit null terminator.

Fix

If you initialize a character array with a literal, avoid specifying the array bounds.

```
char three[]  = "THREE";
```

The compiler automatically allocates space for a null terminator. In the preceding example, the compiler allocates sufficient space for five characters and a null terminator.

If the issue occurs after initialization, you might have to increase the size of the array by one to account for the null terminator.

In certain circumstances, you might want to initialize the character array with a sequence of characters instead of a string. In this situation, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Array size is too small

```
void countdown(int i)
{
    static char one[5]   = "ONE";
    static char two[5]   = "TWO";
    static char three[5] = "THREE";
}
```

The character array `three` has a size of 5 and 5 characters `'T'`, `'H'`, `'R'`, `'E'`, and `'E'`. There is no room for the null character at the end because `three` is only five bytes large.

Correction — Increase Array Size

One possible correction is to change the array size to allow for the five characters plus a null character.

```
void countdown(int i)
{
    static char one[5]   = "ONE";
    static char two[5]   = "TWO";
```

```
    static char three[6] = "THREE";
}
```

Correction — Change Initialization Method

One possible correction is to initialize the string by leaving the array size blank. This initialization method allocates enough memory for the five characters and a terminating-null character.

```
void countdown(int i)
{
    static char one[5]   = "ONE";
    static char two[5]   = "TWO";
    static char three[]  = "THREE";
}
```

Buffer overflow from incorrect string format specifier

Description

Buffer overflow from incorrect string format specifier occurs when the format specifier argument for functions such as `sscanf` leads to an overflow or underflow in the memory buffer argument.

Risk

If the format specifier specifies a precision that is greater than the memory buffer size, an overflow occurs. Overflows can cause unexpected behavior such as memory corruption.

Fix

Use a format specifier that is compatible with the memory buffer size.

Example - Memory Buffer Overflow

```
#include <stdio.h>

void func (char *str[]) {
    char buf[32];
    sscanf(str[1], "%33c", buf);
}
```

In this example, `buf` can contain 32 `char` elements. Therefore, the format specifier `%33c` causes a buffer overflow.

Correction — Use Smaller Precision in Format Specifier

One possible correction is to use a smaller precision in the format specifier.

```
#include <stdio.h>

void func (char *str[]) {
    char buf[32];
    sscanf(str[1], "%32c", buf);
}
```

Destination buffer overflow in string manipulation

Description

Destination buffer overflow in string manipulation occurs when certain string manipulation functions write to their destination buffer argument at an offset greater than the buffer size.

For instance, when calling the function `sprintf(char* buffer, const char* format)`, you use a constant string `format` of greater size than `buffer`.

Risk

Buffer overflow can cause unexpected behavior such as memory corruption or stopping your system. Buffer overflow also introduces the risk of code injection.

Fix

One possible solution is to use alternative functions to constrain the number of characters written. For instance:

- If you use `sprintf` to write formatted data to a string, use `snprintf`, `_snprintf` or `sprintf_s` instead to enforce length control. Alternatively, use `asprintf` to automatically allocate the memory required for the destination buffer.
- If you use `vsprintf` to write formatted data from a variable argument list to a string, use `vsnprintf` or `vsprintf_s` instead to enforce length control.
- If you use `wcscpy` to copy a wide string, use `wcsncpy`, `wcslcpy`, or `wcscpy_s` instead to enforce length control.

Another possible solution is to increase the buffer size.

Example - Buffer Overflow in `sprintf` Use

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";

    sprintf(buffer, fmt_string);
}
```

In this example, `buffer` can contain 20 `char` elements but `fmt_string` has a greater size.

Correction — Use `snprintf` Instead of `sprintf`

One possible correction is to use the `snprintf` function to enforce length control.

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";

    snprintf(buffer, 20, fmt_string);
}
```

Check Information

Group: 05. Characters and Strings (STR)

See Also

External Websites

STR50-CPP

Introduced in R2019a

CERT C++: STR53-CPP

Range check element access

Description

Rule Definition

Range check element access.

Examples

Array access out of bounds

Description

Array access out of bounds occurs when an array index falls outside the range `[0...array_size-1]` during array access.

Risk

Accessing an array outside its bounds is undefined behavior. You can read an unpredictable value or try to access a location that is not allowed and encounter a segmentation fault.

Fix

The fix depends on the root cause of the defect. For instance, you accessed an array inside a loop and one of these situations happened:

- The upper bound of the loop is too large.
- You used an array index that is the same as the loop index instead of being one less than the loop index.

To fix the issue, you have to modify the loop bound or the array index.

Another reason why an array index can exceed array bounds is a prior conversion from signed to unsigned integers. The conversion can result in a wrap around of the index value, eventually causing the array index to exceed the array bounds.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Array Access Out of Bounds Error

```
#include <stdio.h>

void fibonacci(void)
{
    int i;
    int fib[10];

    for (i = 0; i < 10; i++)
       {
        if (i < 2)
            fib[i] = 1;
         else
            fib[i] = fib[i-1] + fib[i-2];
       }

    printf("The 10-th Fibonacci number is %i .\n", fib[i]);
    /* Defect: Value of i is greater than allowed value of 9 */
}
```

The array `fib` is assigned a size of 10. An array index for `fib` has allowed values of `[0,1,2,...,9]`. The variable `i` has a value 10 when it comes out of the `for`-loop. Therefore, the `printf` statement attempts to access `fib[10]` through `i`.

Correction — Keep Array Index Within Array Bounds

One possible correction is to print `fib[i-1]` instead of `fib[i]` after the `for`-loop.

```
#include <stdio.h>
```

```
void fibonacci(void)
{
   int i;
   int fib[10];

   for (i = 0; i < 10; i++)
    {
        if (i < 2)
            fib[i] = 1;
        else
            fib[i] = fib[i-1] + fib[i-2];
    }

    /* Fix: Print fib[9] instead of fib[10] */
    printf("The 10-th Fibonacci number is %i .\n", fib[i-1]);
}
```

The `printf` statement accesses `fib[9]` instead of `fib[10]`.

Array access with tainted index

Description

Array access with tainted index detects reading or writing to an array by using a tainted index that has not been validated.

Risk

The index might be outside the valid array range. If the tainted index is outside the array range, it can cause:

- Buffer underflow/underwrite — writing to memory before the beginning of the buffer.
- Buffer overflow — writing to memory after the end of a buffer.
- Over-reading a buffer — accessing memory after the end of the targeted buffer.
- Under-reading a buffer, or accessing memory before the beginning of the targeted buffer.

An attacker can use an invalid read or write operation create to problems in your program.

Fix

Before using the index to access the array, validate the index value to make sure that it is inside the array range.

Example - Use Index to Return Buffer Value

```
#define SIZE100 100
extern int tab[SIZE100];

int taintedarrayindex(int num) {
    return tab[num];
}
```

In this example, the index `num` accesses the array `tab`. The function does not check to see if `num` is inside the range of `tab`.

Correction — Check Range Before Use

One possible correction is to check that `num` is in range before using it.

```
#define SIZE100 100
extern int tab[SIZE100];

int taintedarrayindex(int num) {
    if (num >= 0 && num < SIZE100) {
           return tab[num];
    } else {
        return -9999;
    }
}
```

Pointer dereference with tainted offset

Description

Pointer dereference with tainted offset detects pointer dereferencing, either reading or writing, using an offset variable from an unknown or unsecure source.

This check focuses on dynamically allocated buffers. For static buffer offsets, see `Array access with tainted index`.

Risk

The index might be outside the valid array range. If the tainted index is outside the array range, it can cause:

- Buffer underflow/underwrite, or writing to memory before the beginning of the buffer.
- Buffer overflow, or writing to memory after the end of a buffer.
- Over reading a buffer, or accessing memory after the end of the targeted buffer.
- Under-reading a buffer, or accessing memory before the beginning of the targeted buffer.

An attacker can use an invalid read or write to compromise your program.

Fix

Validate the index before you use the variable to access the pointer. Check to make sure that the variable is inside the valid range and does not overflow.

Example - Dereference Pointer Array

```
#include <stdlib.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};
extern void read_pint(int*);

int taintedptroffset(int i) {
    int* pint = (int*)calloc(SIZE10, sizeof(int));
    int c = 0;
    if(pint) {
        /* Filling array */
        read_pint(pint);
        c = pint[i];
        free(pint);
    }
    return c;
}
```

In this example, the function initializes an integer pointer `pint`. The pointer is dereferenced using the input index `i`. The value of `i` could be outside the pointer range, causing an out-of-range error.

Correction — Check Index Before Dereference

One possible correction is to validate the value of the index. If the index is inside the valid range, continue with the pointer dereferencing.

```
#include <stdlib.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};
extern void read_pint(int*);

int taintedptroffset(int i) {
    int* pint = (int*)calloc(SIZE10, sizeof(int));
    int c = 0;
    if (pint) {
        /* Filling array */
        read_pint(pint);
        if (i>0 && i<SIZE10) {
            c = pint[i];
        }
        free(pint);
    }
    return c;
}
```

Check Information

Group: 05. Characters and Strings (STR)

See Also

External Websites

STR53-CPP

Introduced in R2019a

06. Memory Management (MEM)

CERT C++: MEM30-C

Do not access freed memory

Description

Rule Definition

Do not access freed memory.

Examples

Use of previously freed pointer

Description

Use of previously freed pointer occurs when you access a block of memory after freeing the block using the `free` function.

Risk

When a pointer is allocated dynamic memory with `malloc`, `calloc` or `realloc`, it points to a memory location on the heap. When you use the `free` function on this pointer, the associated block of memory is freed for reallocation. Trying to access this block of memory can result in unpredictable behavior or even a segmentation fault.

Fix

The fix depends on the root cause of the defect. See if you intended to free the memory later or allocate another memory block to the pointer before access.

As a good practice, after you free a memory block, assign the corresponding pointer to NULL. Before dereferencing pointers, check them for NULL values and handle the error. In this way, you are protected against accessing a freed block.

Example - Use of Previously Freed Pointer Error

```
#include <stdlib.h>
#include <stdio.h>
 int increment_content_of_address(int base_val, int shift)
   {
    int j;
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return 0;

    *pi = base_val;
    free(pi);

    j = *pi + shift;
    /* Defect: Reading a freed pointer */

    return j;
   }
```

The `free` statement releases the block of memory that `pi` refers to. Therefore, dereferencing`pi` after the `free` statement is not valid.

Correction — Free Pointer After Use

One possible correction is to free the pointer `pi` only after the last instance where it is accessed.

```
#include <stdlib.h>

int increment_content_of_address(int base_val, int shift)
{
    int j;
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return 0;

    *pi = base_val;

    j = *pi + shift;
    *pi = 0;

    /* Fix: The pointer is freed after its last use */
    free(pi);
    return j;
}
```

Check Information

Group: 06. Memory Management (MEM)

See Also

External Websites

MEM30-C

Introduced in R2019a

CERT C++: MEM31-C

Free dynamically allocated memory when no longer needed

Description

Rule Definition

Free dynamically allocated memory when no longer needed.

Examples

Memory leak

Description

Memory leak occurs when you do not free a block of memory allocated through `malloc`, `calloc`, `realloc`, or `new`. If the memory is allocated in a function, the defect does not occur if:

- Within the function, you free the memory using `free` or `delete`.
- The function returns the pointer assigned by `malloc`, `calloc`, `realloc`, or `new`.
- The function stores the pointer in a global variable or in a parameter.

Risk

Dynamic memory allocation functions such as `malloc` allocate memory on the heap. If you do not release the memory after use, you reduce the amount of memory available for another allocation. On embedded systems with limited memory, you might end up exhausting available heap memory even during program execution.

Fix

Determine the scope where the dynamically allocated memory is accessed. Free the memory block at the end of this scope.

To free a block of memory, use the `free` function on the pointer that was used during memory allocation. For instance:

```
ptr = (int*)malloc(sizeof(int));
...
free(ptr);
```

It is a good practice to allocate and free memory in the same module at the same level of abstraction. For instance, in this example, `func` allocates and frees memory at the same level but `func2` does not.

```
void func() {
  ptr = (int*)malloc(sizeof(int));
  {
    ...
  }
  free(ptr);
}

void func2() {
  {
   ptr = (int*)malloc(sizeof(int));
   ...
  }
  free(ptr);
}
```

See CERT-C Rule MEM00-C.

Example - Dynamic Memory Not Released Before End of Function

```
#include<stdlib.h>
#include<stdio.h>

void assign_memory(void)
{
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL)
        {
         printf("Memory allocation failed");
         return;
        }


    *pi = 42;
```

```
    /* Defect: pi is not freed */
}
```

In this example, `pi` is dynamically allocated by `malloc`. The function `assign_memory` does not free the memory, nor does it return `pi`.

Correction — Free Memory

One possible correction is to free the memory referenced by `pi` using the `free` function. The `free` function must be called before the function `assign_memory` terminates

```
#include<stdlib.h>
#include<stdio.h>

void assign_memory(void)
{
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL)
        {
         printf("Memory allocation failed");
         return;
        }
    *pi = 42;

    /* Fix: Free the pointer pi*/
    free(pi);
}
```

Correction — Return Pointer from Dynamic Allocation

Another possible correction is to return the pointer `pi`. Returning `pi` allows the function calling `assign_memory` to free the memory block using `pi`.

```
#include<stdlib.h>
#include<stdio.h>

int* assign_memory(void)
{
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL)
        {
            printf("Memory allocation failed");
            return(pi);
        }
```

```
    *pi = 42;

    /* Fix: Return the pointer pi*/
    return(pi);
}
```

Example - Memory Leak with New/Delete

```
#define NULL '\0'

void initialize_arr1(void)
{
    int *p_scalar = new int(5);
}

void initialize_arr2(void)
{
    int *p_array = new int[5];
}
```

In this example, the functions create two variables, `p_scalar` and `p_array`, using the `new` keyword. However, the functions end without cleaning up the memory for these pointers. Because the functions used `new` to create these variables, you must clean up their memory by calling `delete` at the end of each function.

Correction — Add Delete

To correct this error, add a `delete` statement for every `new` initialization. If you used brackets `[]` to instantiate a variable, you must call delete with brackets as well.

```
#define NULL '\0'

void initialize_arrs(void)
{
    int *p_scalar = new int(5);
    int *p_array = new int[5];

    delete p_scalar;
    p_scalar = NULL;

    delete[] p_array;
    p_scalar = NULL;
}
```

Check Information

Group: 06. Memory Management (MEM)

See Also

External Websites

MEM31-C

Introduced in R2019a

CERT C++: MEM34-C

Only free memory allocated dynamically

Description

Rule Definition

Only free memory allocated dynamically.

Examples

Invalid free of pointer

Description

Invalid free of pointer occurs when a block of memory released using the `free` function was not previously allocated using `malloc`, `calloc`, or `realloc`.

Risk

The `free` function releases a block of memory allocated on the heap. If you try to access a location on the heap that you did not allocate previously, a segmentation fault can occur.

The issue can highlight coding errors. For instance, you perhaps wanted to use the `free` function or a previous `malloc` function on a different pointer.

Fix

In most cases, you can fix the issue by removing the `free` statement. If the pointer is not allocated memory from the heap with `malloc` or `calloc`, you do not need to free the pointer. You can simply reuse the pointer as required.

If the issue highlights a coding error such as use of `free` or `malloc` on the wrong pointer, correct the error.

If the issue occurs because you use the `free` function to free memory allocated with the `new` operator, replace the `free` function with the `delete` operator.

Example - Invalid Free of Pointer Error

```
#include <stdlib.h>

void Assign_Ones(void)
{
  int p[10];
  for(int i=0;i<10;i++)
     *(p+i)=1;

  free(p);
  /* Defect: p does not point to dynamically allocated memory */
}
```

The pointer `p` is deallocated using the `free` function. However, `p` points to a memory location that was not dynamically allocated.

Correction — Remove Pointer Deallocation

If the number of elements of the array `p` is known at compile time, one possible correction is to remove the deallocation of the pointer `p`.

```
#include <stdlib.h>

void Assign_Ones(void)
 {
  int p[10];
  for(int i=0;i<10;i++)
     *(p+i)=1;
  /* Fix: Remove deallocation of p */
 }
```

Correction — Introduce Pointer Allocation

If the number of elements of the array `p` is not known at compile time, one possible correction is to dynamically allocate memory to the array `p`.

```
#include <stdlib.h>

void Assign_Ones(int num)
{
```

```
  int *p;
  /* Fix: Allocate memory dynamically to p */
  p=(int*) calloc(10,sizeof(int));
  for(int i=0;i<10;i++)
     *(p+i)=1;
  free(p);
}
```

Check Information

Group: 06. Memory Management (MEM)

See Also

External Websites

MEM34-C

Introduced in R2019a

CERT C++: MEM35-C

Allocate sufficient memory for an object

Description

Rule Definition

Allocate sufficient memory for an object.

Examples

Pointer access out of bounds

Description

Pointer access out of bounds occurs when a pointer is dereferenced outside its bounds.

When a pointer is assigned an address, a block of memory is associated with the pointer. You cannot access memory beyond that block using the pointer.

Risk

Dereferencing a pointer outside its bounds is undefined behavior. You can read an unpredictable value or try to access a location that is not allowed and encounter a segmentation fault.

Fix

The fix depends on the root cause of the defect. For instance, you dereferenced a pointer inside a loop and one of these situations happened:

- The upper bound of the loop is too large.
- You used pointer arithmetic to advance the pointer with an incorrect value for the pointer increment.

To fix the issue, you have to modify the loop bound or the pointer increment value.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Pointer access out of bounds error

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
   {
    ptr++;
    *ptr=i;
    /* Defect: ptr out of bounds for i=9 */
   }

 return(arr);
}
```

`ptr` is assigned the address `arr` that points to a memory block of size `10*sizeof(int)`. In the `for`-loop, `ptr` is incremented 10 times. In the last iteration of the loop, `ptr` points outside the memory block assigned to it. Therefore, it cannot be dereferenced.

Correction — Check Pointer Stays Within Bounds

One possible correction is to reverse the order of increment and dereference of `ptr`.

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
     {
```

```
      /* Fix: Dereference pointer before increment */
      *ptr=i;
      ptr++;
     }

 return(arr);
}
```

After the last increment, even though `ptr` points outside the memory block assigned to it, it is not dereferenced more.

Memory allocation with tainted size

Description

Memory allocation with tainted size checks memory allocation functions, such as `calloc` or `malloc`, for size arguments from unsecured sources.

Risk

Uncontrolled memory allocation can cause your program to request too much system memory. This consequence can lead to a crash due to an out-of-memory condition, or assigning too many resources.

Fix

Before allocating memory, check the value of your arguments to check that they do not exceed the bounds.

Example - Allocate Memory Using Input Argument

```
#include "stdlib.h"

int* bug_taintedmemoryallocsize(size_t size) {
    int* p = (int*)malloc(size);
    return p;
}
```

In this example, `malloc` allocates `size` amount of memory for the pointer `p`. `size` is an outside variable, so could be any size value. If the size is larger than the amount of memory you have available, your program could crash.

Correction — Check Size of Memory to be Allocated

One possible correction is to check the size of the memory that you want to allocate before performing the `malloc` operation. This example checks to see if the size is positive and less than the maximum size.

```
#include "stdlib.h"

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int* corrected_taintedmemoryallocsize(int size) {
    int* p = NULL;
    if (size>0 && size<SIZE128) {          /* Fix: Check entry range before use */
        p = (int*)malloc((unsigned int)size);
    }
    return p;
}
```

Check Information

Group: 06. Memory Management (MEM)

See Also

External Websites

MEM35-C

Introduced in R2019a

CERT C++: MEM36-C

Do not modify the alignment of objects by calling realloc()

Description

Rule Definition

Do not modify the alignment of objects by calling realloc().

Examples

Alignment changed after memory reallocation

Description

Alignment changed after memory reallocation occurs when you use `realloc()` to modify the size of objects with strict memory alignment requirements.

Risk

The pointer returned by `realloc()` can be suitably assigned to objects with less strict alignment requirements. A misaligned memory allocation can lead to buffer underflow or overflow, an illegally dereferenced pointer, or access to arbitrary memory locations. In processors that support misaligned memory, the allocation impacts the performance of the system.

Fix

To reallocate memory:

1. Resize the memory block.

   - In Windows, use `_aligned_realloc()` with the alignment argument used in `_aligned_malloc()` to allocate the original memory block.

- In UNIX/Linux, use the same function with the same alignment argument used to allocate the original memory block.

2 Copy the original content to the new memory block.

3 Free the original memory block.

Note This fix has implementation-defined behavior. The implementation might not support the requested memory alignment and can have additional constraints for the size of the new memory.

Example - Memory Reallocated Without Preserving the Original Alignment

```
#include <stdio.h>
#include <stdlib.h>

#define SIZE1024 1024

void func(void)
{
    size_t resize = SIZE1024;
    size_t alignment = 1 << 12; /* 4096 bytes alignment */
    int *ptr = NULL;
    int *ptr1;

    /* Allocate memory with 4096 bytes alignment */

    if (posix_memalign((void **)&ptr, alignment, sizeof(int)) != 0)
    {
        /* Handle error */
      }

    /*Reallocate memory without using the original alignment.
    ptr1 may not be 4096 bytes aligned. */

    ptr1 = (int *)realloc(ptr, sizeof(int) * resize);

    if (ptr1 == NULL)
    {
        /* Handle error */
    }

    /* Processing using ptr1 */
```

```
    /* Free before exit */
    free(ptr1);
}
```

In this example, the allocated memory is 4096-bytes aligned. `realloc()` then resizes the allocated memory. The new pointer `ptr1` might not be 4096-bytes aligned.

Correction — Specify the Alignment for the Reallocated Memory

When you reallocate the memory, use `posix_memalign()` and pass the alignment argument that you used to allocate the original memory.

```
#include <stdio.h>
#include <stdlib.h>

#define SIZE1024 1024

void func(void)
{
    size_t resize = SIZE1024;
    size_t alignment = 1 << 12; /* 4096 bytes alignment */
    int *ptr = NULL;

    /* Allocate memory with 4096 bytes alignment */
    if (posix_memalign((void **)&ptr, alignment, sizeof(int)) != 0)
    {
        /* Handle error */
    }

    /* Reallocate memory using the original alignment. */
    if (posix_memalign((void **)&ptr, alignment, sizeof(int) * resize) != 0)
    {
        /* Handle error */
        free(ptr);
        ptr = NULL;
    }

    /* Processing using ptr */

    /* Free before exit */
```

```
    free(ptr);
}
```

Check Information

Group: 06. Memory Management (MEM)

See Also

External Websites

MEM36-C

Introduced in R2019a

CERT C++: MEM50-CPP

Do not access freed memory

Description

Rule Definition

Do not access freed memory.

Examples

Pointer access out of bounds

Description

Pointer access out of bounds occurs when a pointer is dereferenced outside its bounds.

When a pointer is assigned an address, a block of memory is associated with the pointer. You cannot access memory beyond that block using the pointer.

Risk

Dereferencing a pointer outside its bounds is undefined behavior. You can read an unpredictable value or try to access a location that is not allowed and encounter a segmentation fault.

Fix

The fix depends on the root cause of the defect. For instance, you dereferenced a pointer inside a loop and one of these situations happened:

- The upper bound of the loop is too large.
- You used pointer arithmetic to advance the pointer with an incorrect value for the pointer increment.

To fix the issue, you have to modify the loop bound or the pointer increment value.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Pointer access out of bounds error

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
   {
    ptr++;
    *ptr=i;
    /* Defect: ptr out of bounds for i=9 */
   }

 return(arr);
}
```

`ptr` is assigned the address `arr` that points to a memory block of size `10*sizeof(int)`. In the `for`-loop, `ptr` is incremented 10 times. In the last iteration of the loop, `ptr` points outside the memory block assigned to it. Therefore, it cannot be dereferenced.

Correction — Check Pointer Stays Within Bounds

One possible correction is to reverse the order of increment and dereference of `ptr`.

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
     {
```

```
      /* Fix: Dereference pointer before increment */
      *ptr=i;
      ptr++;
     }

 return(arr);
}
```

After the last increment, even though `ptr` points outside the memory block assigned to it, it is not dereferenced more.

Deallocation of previously deallocated pointer

Description

Deallocation of previously deallocated pointer occurs when a block of memory is freed more than once using the `free` function without an intermediate allocation.

Risk

When a pointer is allocated dynamic memory with `malloc`, `calloc` or `realloc`, it points to a memory location on the heap. When you use the `free` function on this pointer, the associated block of memory is freed for reallocation. Trying to free this block of memory can result in a segmentation fault.

Fix

The fix depends on the root cause of the defect. See if you intended to allocate a memory block to the pointer between the first deallocation and the second. Otherwise, remove the second `free` statement.

As a good practice, after you free a memory block, assign the corresponding pointer to NULL. Before freeing pointers, check them for NULL values and handle the error. In this way, you are protected against freeing an already freed block.

Example - Deallocation of Previously Deallocated Pointer Error

```
#include <stdlib.h>

void allocate_and_free(void)
{

    int* pi = (int*)malloc(sizeof(int));
```

```
    if (pi == NULL) return;

    *pi = 2;
    free(pi);
    free (pi);
    /* Defect: pi has already been freed */
}
```

The first `free` statement releases the block of memory that `pi` refers to. The second `free` statement on `pi` releases a block of memory that has been freed already.

Correction — Remove Duplicate Deallocation

One possible correction is to remove the second `free` statement.

```
#include <stdlib.h>

void allocate_and_free(void)
{

    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return;

    *pi = 2;
    free(pi);
    /* Fix: remove second deallocation */
 }
```

Use of previously freed pointer

Description

Use of previously freed pointer occurs when you access a block of memory after freeing the block using the `free` function.

Risk

When a pointer is allocated dynamic memory with `malloc`, `calloc` or `realloc`, it points to a memory location on the heap. When you use the `free` function on this pointer, the associated block of memory is freed for reallocation. Trying to access this block of memory can result in unpredictable behavior or even a segmentation fault.

Fix

The fix depends on the root cause of the defect. See if you intended to free the memory later or allocate another memory block to the pointer before access.

As a good practice, after you free a memory block, assign the corresponding pointer to NULL. Before dereferencing pointers, check them for NULL values and handle the error. In this way, you are protected against accessing a freed block.

Example - Use of Previously Freed Pointer Error

```
#include <stdlib.h>
#include <stdio.h>
 int increment_content_of_address(int base_val, int shift)
   {
    int j;
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return 0;

    *pi = base_val;
    free(pi);

    j = *pi + shift;
    /* Defect: Reading a freed pointer */

    return j;
   }
```

The `free` statement releases the block of memory that `pi` refers to. Therefore, dereferencing`pi` after the `free` statement is not valid.

Correction — Free Pointer After Use

One possible correction is to free the pointer `pi` only after the last instance where it is accessed.

```
#include <stdlib.h>

int increment_content_of_address(int base_val, int shift)
{
    int j;
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return 0;
```

```
    *pi = base_val;

    j = *pi + shift;
    *pi = 0;

    /* Fix: The pointer is freed after its last use */
    free(pi);
    return j;
}
```

Check Information

Group: 06. Memory Management (MEM)

See Also

External Websites

MEM50-CPP

Introduced in R2019a

CERT C++: MEM51-CPP

Properly deallocate dynamically allocated resources

Description

Rule Definition

Properly deallocate dynamically allocated resources.

Examples

Invalid deletion of pointer

Description

Invalid deletion of pointer occurs when:

- You release a block of memory with the `delete` operator but the memory was previously not allocated with the `new` operator.
- You release a block of memory with the `delete` operator using the single-object notation but the memory was previously allocated as an array with the `new` operator.

This defect applies only to C++ source files.

Risk

The risk depends on the cause of the issue:

- The `delete` operator releases a block of memory allocated on the heap. If you try to access a location on the heap that you did not allocate previously, a segmentation fault can occur.
- If you use the single-object notation for `delete` on a pointer that is previously allocated with the array notation for `new`, the behavior is undefined.

The issue can also highlight other coding errors. For instance, you perhaps wanted to use the `delete` operator or a previous `new` operator on a different pointer.

Fix

The fix depends on the cause of the issue:

- In most cases, you can fix the issue by removing the `delete` statement. If the pointer is not allocated memory from the heap with the `new` operator, you do not need to release the pointer with `delete`. You can simply reuse the pointer as required or let the object be destroyed at the end of its scope.
- In case of mismatched notation for `new` and `delete`, correct the mismatch. For instance, to allocate and deallocate a single object, use this notation:

  ```
  classType* ptr = new classType;
  delete ptr;
  ```

  To allocate and deallocate an array objects, use this notation:

  ```
  classType* p2 = new classType[10];
  delete[] p2;
  ```

If the issue highlights a coding error such as use of `delete` or `new` on the wrong pointer, correct the error.

Example - Deleting Static Memory

```
void assign_ones(void)
{
    int ptr[10];

    for(int i=0;i<10;i++)
        *(ptr+i)=1;

    delete[] ptr;
}
```

The pointer `ptr` is released using the `delete` operator. However, `ptr` points to a memory location that was not dynamically allocated.

Correction: Remove Pointer Deallocation

If the number of elements of the array `ptr` is known at compile time, one possible correction is to remove the deallocation of the pointer `ptr`.

```
void assign_ones(void)
{
    int ptr[10];

    for(int i=0;i<10;i++)
        *(ptr+i)=1;
}
```

Correction — Add Pointer Allocation

If the number of array elements is not known at compile time, one possible correction is to dynamically allocate memory to the array `ptr` using the `new` operator.

```
void assign_ones(int num)
{
    int *ptr = new int[num];

    for(int i=0; i < num; i++)
        *(ptr+i) = 1;

    delete[] ptr;
   }
```

Example - Mismatched `new` and `delete`

```
int main (void)
{
    int *p_scale = new int[5];

    //more code using scal

    delete p_scale;
}
```

In this example, `p_scale` is initialized to an array of size 5 using `new int[5]`. However, `p_scale` is deleted with `delete` instead of `delete[]`. The `new`-`delete` pair does not match. Do not use `delete` without the brackets when deleting arrays.

Correction — Match `delete` to `new`

One possible correction is to add brackets so the `delete` matches the `new []` declaration.

```
int main (void)
{
```

```
    int *p_scale = new int[5];

    //more code using p_scale

    delete[] p_scale;
}
```

Correction — Match `new` to `delete`

Another possible correction is to change the declaration of `p_scale`. If you meant to initialize `p_scale` as 5 itself instead of an array of size 5, you must use different syntax. For this correction, change the square brackets in the initialization to parentheses. Leave the `delete` statement as it is.

```
int main (void)
{
    int *p_scale = new int(5);

    //more code using p_scale

    delete p_scale;
}
```

Invalid free of pointer

Description

Invalid free of pointer occurs when a block of memory released using the `free` function was not previously allocated using `malloc`, `calloc`, or `realloc`.

Risk

The `free` function releases a block of memory allocated on the heap. If you try to access a location on the heap that you did not allocate previously, a segmentation fault can occur.

The issue can highlight coding errors. For instance, you perhaps wanted to use the `free` function or a previous `malloc` function on a different pointer.

Fix

In most cases, you can fix the issue by removing the `free` statement. If the pointer is not allocated memory from the heap with `malloc` or `calloc`, you do not need to free the pointer. You can simply reuse the pointer as required.

If the issue highlights a coding error such as use of `free` or `malloc` on the wrong pointer, correct the error.

If the issue occurs because you use the `free` function to free memory allocated with the `new` operator, replace the `free` function with the `delete` operator.

Example - Invalid Free of Pointer Error

```
#include <stdlib.h>

void Assign_Ones(void)
{
  int p[10];
  for(int i=0;i<10;i++)
     *(p+i)=1;

  free(p);
  /* Defect: p does not point to dynamically allocated memory */
}
```

The pointer `p` is deallocated using the `free` function. However, `p` points to a memory location that was not dynamically allocated.

Correction — Remove Pointer Deallocation

If the number of elements of the array `p` is known at compile time, one possible correction is to remove the deallocation of the pointer `p`.

```
#include <stdlib.h>

void Assign_Ones(void)
 {
  int p[10];
  for(int i=0;i<10;i++)
     *(p+i)=1;
  /* Fix: Remove deallocation of p */
 }
```

Correction — Introduce Pointer Allocation

If the number of elements of the array `p` is not known at compile time, one possible correction is to dynamically allocate memory to the array `p`.

```
#include <stdlib.h>
```

```
void Assign_Ones(int num)
{
  int *p;
  /* Fix: Allocate memory dynamically to p */
  p=(int*) calloc(10,sizeof(int));
  for(int i=0;i<10;i++)
     *(p+i)=1;
  free(p);
}
```

Deallocation of previously deallocated pointer

Description

Deallocation of previously deallocated pointer occurs when a block of memory is freed more than once using the `free` function without an intermediate allocation.

Risk

When a pointer is allocated dynamic memory with `malloc`, `calloc` or `realloc`, it points to a memory location on the heap. When you use the `free` function on this pointer, the associated block of memory is freed for reallocation. Trying to free this block of memory can result in a segmentation fault.

Fix

The fix depends on the root cause of the defect. See if you intended to allocate a memory block to the pointer between the first deallocation and the second. Otherwise, remove the second `free` statement.

As a good practice, after you free a memory block, assign the corresponding pointer to NULL. Before freeing pointers, check them for NULL values and handle the error. In this way, you are protected against freeing an already freed block.

Example - Deallocation of Previously Deallocated Pointer Error

```
#include <stdlib.h>

void allocate_and_free(void)
{

    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return;
```

```
    *pi = 2;
    free(pi);
    free (pi);
    /* Defect: pi has already been freed */
}
```

The first `free` statement releases the block of memory that `pi` refers to. The second `free` statement on `pi` releases a block of memory that has been freed already.

Correction — Remove Duplicate Deallocation

One possible correction is to remove the second `free` statement.

```
#include <stdlib.h>

void allocate_and_free(void)
{

    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return;

    *pi = 2;
    free(pi);
    /* Fix: remove second deallocation */
 }
```

Check Information

Group: 06. Memory Management (MEM)

See Also

External Websites

MEM51-CPP

Introduced in R2019a

CERT C++: MEM52-CPP

Detect and handle memory allocation errors

Description

Rule Definition

Detect and handle memory allocation errors.

Examples

Unprotected dynamic memory allocation

Description

Unprotected dynamic memory allocation occurs when you do not check after dynamic memory allocation whether the memory allocation succeeded.

Risk

When memory is dynamically allocated using `malloc`, `calloc`, or `realloc`, it returns a value `NULL` if the requested memory is not available. If the code following the allocation accesses the memory block without checking for this `NULL` value, this access is not protected from failures.

Fix

Check the return value of `malloc`, `calloc`, or `realloc` for NULL before accessing the allocated memory location.

```
int *ptr = malloc(size * sizeof(int));

if(ptr) /* Check for NULL */
{
   /* Memory access through ptr */
}
```

Example - Unprotected dynamic memory allocation error

```
#include <stdlib.h>

void Assign_Value(void)
{
  int* p = (int*)calloc(5, sizeof(int));

  *p = 2;
  /* Defect: p is not checked for NULL value */

  free(p);
}
```

If the memory allocation fails, the function `calloc` returns `NULL` to `p`. Before accessing the memory through `p`, the code does not check whether `p` is `NULL`

Correction — Check for NULL Value

One possible correction is to check whether `p` has value `NULL` before dereference.

```
#include <stdlib.h>

void Assign_Value(void)
 {
   int* p = (int*)calloc(5, sizeof(int));

   /* Fix: Check if p is NULL */
   if(p!=NULL) *p = 2;

   free(p);
 }
```

Check Information

Group: 06. Memory Management (MEM)

See Also

External Websites

MEM52-CPP

Introduced in R2019a

07. Input Output (FIO)

CERT C++: FIO30-C

Exclude user input from format strings

Description

Rule Definition

Exclude user input from format strings.

Examples

Tainted string format

Description

Tainted string format detects string formatting with `printf`-style functions that contain elements from unsecure sources.

Risk

If you use externally controlled elements to format a string, you can cause buffer overflow or data-representation problems. An attacker can use these string formatting elements to view the contents of a stack using `%x` or write to a stack using `%n`.

Fix

Pass a static string to format string functions. This fix ensures that an external actor cannot control the string.

Another possible fix is to allow only the expected number of arguments. If possible, use functions that do not support the vulnerable `%n` operator in format strings.

Example - Get Elements from User Input

```
#include "stdio.h"
```

```
void taintedstringformat(char* userstr) {
    printf(userstr);
}
```

This example prints the input argument `userstr`. The string is unknown. If it contains elements such as `%`, `printf` can interpret `userstr` as a string format instead of a string, causing your program to crash.

Correction — Print as String

One possible correction is to print `userstr` explicitly as a string so that there is no ambiguity.

```
#include "stdio.h"

void taintedstringformat(char* userstr) {
    printf("%.20s", userstr);
}
```

Check Information

Group: 07. Input Output (FIO)

See Also

External Websites

FIO30-C

Introduced in R2019a

CERT C++: FIO32-C

Do not perform operations on devices that are only appropriate for files

Description

Rule Definition

Do not perform operations on devices that are only appropriate for files.

Examples

Inappropriate I/O operation on device files

Description

Inappropriate I/O operation on device files occurs when you do not check whether a file name parameter refers to a device file before you pass it to these functions:

- `fopen()`
- `fopen_s()`
- `freopen()`
- `remove()`
- `rename()`
- `CreateFile()`
- `CreateFileA()`
- `CreateFileW()`
- `_wfopen()`
- `_wfopen_s()`

Device files are files in a file system that provide an interface to device drivers. You can use these files to interact with devices.

Inappropriate I/O operation on device files does not raise a defect when:

- You use `stat` or `lstat`-family functions to check the file name parameter before calling the previously listed functions.
- You use a string comparison function to compare the file name against a list of device file names.

Risk

Operations appropriate only for regular files but performed on device files can result in denial-of-service attacks, other security vulnerabilities, or system failures.

Fix

Before you perform an I/O operation on a file:

- Use `stat()`, `lstat()`, or an equivalent function to check whether the file name parameter refers to a regular file.
- Use a string comparison function to compare the file name against a list of device file names.

Example - Using `fopen()` Without Checking `file_name`

```
#include <stdio.h>
#include <string.h>

#define SIZE1024 1024

FILE* func()
{

    FILE* f;
    const char file_name[SIZE1024] = "./tmp/file";

    if ((f = fopen(file_name, "w")) == NULL) {
        /*handle error */
    };
    /*operate on file */
}
```

In this example, `func()` operates on the file `file_name` without checking whether it is a regular file. If `file_name` is a device file, attempts to access it can result in a system failure.

Correction — Check File with `lstat()` Before Calling `fopen()`

One possible correction is to use `lstat()` and the `S_ISREG` macro to check whether the file is a regular file. This solution contains a `TOCTOU` race condition that can allow an attacker to modify the file after you check it but before the call to fopen(). To prevent this vulnerability, ensure that `file_name` refers to a file in a secure folder.

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include <sys/stat.h>

#define SIZE1024 1024

FILE* func()
{

    FILE* f;
    const char file_name[SIZE1024] = "./tmp/file";
    struct stat orig_st;
    if ((lstat(file_name, &orig_st) != 0) ||
        (!S_ISREG(orig_st.st_mode))) {
        exit(0);
    }
    if ((f = fopen(file_name, "w")) == NULL) {
        /*handle error */
    };
    /*operate on file */
}
```

Check Information

Group: 07. Input Output (FIO)

See Also

External Websites

FIO32-C

Introduced in R2019a

CERT C++: FIO34-C

Distinguish between characters read from a file and EOF or WEOF

Description

Rule Definition

Distinguish between characters read from a file and EOF or WEOF.

Examples

Character value absorbed into EOF

Description

Character value absorbed into EOF occurs when you perform a data type conversion that makes a valid character value indistinguishable from `EOF` (End-of-File). Bug Finder flags the defect in one of the following situations:

- *End-of-File*: You perform a data type conversion such as from `int` to `char` that converts a non-EOF character value into `EOF`.

  ```
  char ch = (char)getchar()
  ```

  You then compare the result with EOF.

  ```
  if((int)ch == EOF)
  ```

  The conversion can be explicit or implicit.
- *Wide End-of-File*: You perform a data type conversion that can convert a non-WEOF wide character value into WEOF, and then compare the result with WEOF.

Risk

The data type `char` cannot hold the value `EOF` that indicates the end of a file. Functions such as `getchar` have return type `int` to accommodate `EOF`. If you convert from `int` to

`char`, the values `UCHAR_MAX` (a valid character value) and `EOF` get converted to the same value -1 and become indistinguishable from each other. When you compare the result of this conversion with `EOF`, the comparison can lead to false detection of `EOF`. This rationale also applies to wide character values and `WEOF`.

Fix

Perform the comparison with `EOF` or `WEOF` before conversion.

Example - Return Value of `getchar` Converted to `char`

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

char func(void)
{
    char ch;
    ch = getchar();
    if (EOF == (int)ch) {
        fatal_error();
    }
    return ch;
}
```

In this example, the return value of `getchar` is implicitly converted to `char`. If `getchar` returns `UCHAR_MAX`, it is converted to -1, which is indistinguishable from EOF. When you compare with EOF later, it can lead to a false positive.

Correction — Perform Comparison with EOF Before Conversion

One possible correction is to first perform the comparison with EOF, and then convert from `int` to `char`.

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

char func(void)
{
    int i;
    i = getchar();
    if (EOF == i) {
        fatal_error();
```

```
    }
    else {
        return (char)i;
    }
}
```

Check Information

Group: 07. Input Output (FIO)

See Also

External Websites

FIO34-C

Introduced in R2019a

CERT C++: FIO37-C

Do not assume that fgets() or fgetws() returns a nonempty string when successful

Description

Rule Definition

Do not assume that fgets() or fgetws() returns a nonempty string when successful.

Examples

Use of indeterminate string

Description

Use of indeterminate string occurs when you do not check the validity of the buffer returned from `fgets`-family functions. The checker raises a defect when such a buffer is used as:

- An argument in standard functions that print or manipulate strings or wide strings.
- A return value.
- An argument in external functions with parameter type `const char *` or `const wchar_t *`.

Risk

If an `fgets`-family function fails, the content of its output buffer is indeterminate. Use of such a buffer has undefined behavior and can result in a program that stops working or other security vulnerabilities.

Fix

Reset the output buffer of an `fgets`-family function to a known string value when the function fails.

Example - Output of `fgets()` Passed to External Function

```
#include <stdio.h>
#include <wchar.h>
#include <string.h>
#include <stdlib.h>

#define SIZE20 20

extern void display_text(const char *txt);

void func(void) {
    char buf[SIZE20];

    /* Check fgets() error */
    if (fgets (buf, sizeof (buf), stdin) == NULL)
    {
        /* 'buf' may contain an indeterminate string.  */
        ;
    }
    /* 'buf passed to external function */
    display_text(buf);
}
```

In this example, the output `buf` is passed to the external function `display_text()`, but its value is not reset if `fgets()` fails.

Correction — Reset `fgets()` Output on Failure

If `fgets()` fails, reset `buf` to a known value before you pass it to an external function.

```
#include <stdio.h>
#include <wchar.h>
#include <string.h>
#include <stdlib.h>

#define SIZE20 20

extern void display_text(const char *txt);

void func1(void) {
    char buf[SIZE20];
    /* Check fgets() error */
```

```
    if (fgets (buf, sizeof (buf), stdin) == NULL)
    {
        /* value of 'buf' reset after fgets() failure. */
        buf[0] = '\0';
    }
    /* 'buf' passed to external function */
    display_text(buf);
}
```

Check Information

Group: 07. Input Output (FIO)

See Also

External Websites

FIO37-C

Introduced in R2019a

CERT C++: FIO38-C

Do not copy a FILE object

Description

Rule Definition

Do not copy a FILE object.

Examples

Misuse of a FILE object

Description

Misuse of a FILE object occurs when:

- You dereference a pointer to a FILE object, including indirect dereference by using `memcmp()`.
- You modify an entire FILE object or one of its components through its pointer.
- You take the address of FILE object that was not returned from a call to an `fopen`-family function. No defect is raised if a macro defines the pointer as the address of a built-in FILE object, such as `#define ptr (&__stdout)`.

Risk

In some implementations, the address of the pointer to a FILE object used to control a stream is significant. A pointer to a copy of a FILE object is interpreted differently than a pointer to the original object, and can potentially result in operations on the wrong stream. Therefore, the use of a copy of a FILE object can cause the software to stop responding, which an attacker might exploit in denial-of-service attacks.

Fix

Do not make a copy of a FILE object. Do not use the address of a FILE object that was not returned from a successful call to an `fopen`-family function.

Example - Copy of FILE Object Used in `fputs()`

```
#include <stdio.h>
#include <unistd.h>
#include <stdlib.h>
#include <string.h>
#include <strings.h>

void fatal_error(void);

int func(void)
{
    /*'stdout' dereferenced and contents
        copied to 'my_stdout'. */
    FILE my_stdout = *stdout;

    /* Address of 'my_stdout' may not point to correct stream. */
    if (fputs("Hello, World!\n", &my_stdout) == EOF)
    {
        /* Handler error */
        fatal_error();
    }
    return 0;
}
```

In this example, FILE object `stdout` is dereferenced and its contents are copied to `my_stdout`. The contents of `stdout` might not be significant. `fputs()` is then called with the address of `my_stdout` as an argument. Because no call to `fopen()` or a similar function was made, the address of `my_stdout` might not point to the correct stream.

Correction — Copy the FILE Object Pointer

Declare `my_stdout` to point to the same address as `stdout` to ensure that you write to the correct stream when you call `fputs()`.

```
#include <stdio.h>
#include <unistd.h>
```

```
#include <stdlib.h>
#include <string.h>
#include <strings.h>

void fatal_error(void);

int func(void)
{
    /* 'my_stdout' and 'stdout' point to the same object. */
    FILE *my_stdout = stdout;
    if (fputs("Hello, World!\n", my_stdout) == EOF)
    {
        /* Handler error */
        fatal_error();
    }
    return 0;
}
```

Check Information

Group: 07. Input Output (FIO)

See Also

External Websites

FIO38-C

Introduced in R2019a

CERT C++: FIO39-C

Do not alternately input and output from a stream without an intervening flush or positioning call

Description

Rule Definition

Do not alternately input and output from a stream without an intervening flush or positioning call.

Examples

Alternating input and output from a stream without flush or positioning call

Description

Alternating input and output from a stream without flush or positioning call occurs when:

- You do not perform a flush or function positioning call between an output operation and a following input operation on a file stream in update mode.
- You do not perform a function positioning call between an input operation and a following output operation on a file stream in update mode.

Risk

Alternating input and output operations on a stream without an intervening flush or positioning call is undefined behavior.

Fix

Call `fflush()` or a file positioning function such as `fseek()` or `fsetpos()` between output and input operations on an update stream.

Call a file positioning function between input and output operations on an update stream.

Example - Read After Write Without Intervening Flush

```
#include <stdio.h>
#define SIZE20 20

void initialize_data(char* data, size_t s) {};
const char *temp_filename = "/tmp/demo.txt";

void func()
{
    char data[SIZE20];
    char append_data[SIZE20];
    FILE *file;

    file = fopen(temp_filename, "a+");
    if (file == NULL)
      {
        /* Handle error. */;
      }

    initialize_data(append_data, SIZE20);

    if (fwrite(append_data, 1, SIZE20, file) != SIZE20)
      {
        (void)fclose(file);
        /* Handle error. */;
      }
    /* Read operation after write without
    intervening flush. */
    if (fread(data, 1, SIZE20, file) < SIZE20)
      {
          (void)fclose(file);
          /* Handle error. */;
      }

    if (fclose(file) == EOF)
      {
        /* Handle error. */;
      }
}
```

In this example, the file `demo.txt` is opened for reading and appending. After the call to `fwrite()`, a call to `fread()` without an intervening flush operation is undefined behavior.

Correction — Call `fflush()` Before the Read Operation

After writing data to the file, before calling `fread()`, perform a flush call.

```
#include <stdio.h>
#define SIZE20 20

void initialize_data(char* data, size_t s) {};
const char *temp_filename = "/tmp/demo.txt";


void func()
{
    char data[SIZE20];
    char append_data[SIZE20];
    FILE *file;

    file = fopen(temp_filename, "a+");
    if (file == NULL)
      {
        /* Handle error. */;
      }

    initialize_data(append_data, SIZE20);

    if (fwrite(append_data, 1, SIZE20, file) != SIZE20)
      {
        (void)fclose(file);
        /* Handle error. */;
      }
    /* Buffer flush after write and before read */
    if (fflush(file) != 0)
      {
        (void)fclose(file);
        /* Handle error. */;
      }
    if (fread(data, 1, SIZE20, file) < SIZE20)
      {
        (void)fclose(file);
        /* Handle error. */;
```

```
      }

    if (fclose(file) == EOF)
      {
        /* Handle error. */;
      }
}
```

Check Information

Group: 07. Input Output (FIO)

See Also

External Websites

FIO39-C

Introduced in R2019a

CERT C++: FIO40-C

Reset strings on fgets() or fgetws() failure

Description

Rule Definition

Reset strings on fgets() or fgetws() failure.

Examples

Use of indeterminate string

Description

Use of indeterminate string occurs when you do not check the validity of the buffer returned from `fgets`-family functions. The checker raises a defect when such a buffer is used as:

- An argument in standard functions that print or manipulate strings or wide strings.
- A return value.
- An argument in external functions with parameter type `const char *` or `const wchar_t *`.

Risk

If an `fgets`-family function fails, the content of its output buffer is indeterminate. Use of such a buffer has undefined behavior and can result in a program that stops working or other security vulnerabilities.

Fix

Reset the output buffer of an `fgets`-family function to a known string value when the function fails.

Example - Output of `fgets()` Passed to External Function

```
#include <stdio.h>
#include <wchar.h>
#include <string.h>
#include <stdlib.h>

#define SIZE20 20

extern void display_text(const char *txt);

void func(void) {
    char buf[SIZE20];

    /* Check fgets() error */
    if (fgets (buf, sizeof (buf), stdin) == NULL)
    {
        /* 'buf' may contain an indeterminate string.  */
        ;
    }
    /* 'buf passed to external function */
    display_text(buf);
}
```

In this example, the output `buf` is passed to the external function `display_text()`, but its value is not reset if `fgets()` fails.

Correction — Reset `fgets()` Output on Failure

If `fgets()` fails, reset `buf` to a known value before you pass it to an external function.

```
#include <stdio.h>
#include <wchar.h>
#include <string.h>
#include <stdlib.h>

#define SIZE20 20

extern void display_text(const char *txt);

void func1(void) {
    char buf[SIZE20];
    /* Check fgets() error */
```

```
    if (fgets (buf, sizeof (buf), stdin) == NULL)
    {
        /* value of 'buf' reset after fgets() failure. */
        buf[0] = '\0';
    }
    /* 'buf' passed to external function */
    display_text(buf);
}
```

Check Information

Group: 07. Input Output (FIO)

See Also

External Websites

FIO40-C

Introduced in R2019a

CERT C++: FIO41-C

Do not call getc(), putc(), getwc(), or putwc() with a stream argument that has side effects

Description

Rule Definition

Do not call getc(), putc(), getwc(), or putwc() with a stream argument that has side effects.

Examples

Stream argument with possibly unintended side effects

Description

Stream argument with possibly unintended side effects occurs when you call `getc()`, `putc()`, `getwc()`, or `putwc()` with a stream argument that has side effects.

Stream argument with possibly unintended side effects considers the following as stream side effects:

- Any assignment of a variable of a stream, such as `FILE *`, or any assignment of a variable of a deeper stream type, such as an array of `FILE *`.
- Any call to a function that manipulates a stream or a deeper stream type.

The number of defects raised corresponds to the number of side effects detected. When a stream argument is evaluated multiple times in a function implemented as a macro, a defect is raised for each evaluation that has a side effect.

A defect is also raised on functions that are not implemented as macros but that can be implemented as macros on another operating system.

Risk

If the function is implemented as an unsafe macro, the stream argument can be evaluated more than once, and the stream side effect happens multiple times. For instance, a stream argument calling `fopen()` might open the same file multiple times, which is unspecified behavior.

Fix

To ensure that the side effect of a stream happens only once, use a separate statement for the stream argument.

Example - Stream Argument of `getc()` Has Side Effect `fopen()`

```
#include <stddef.h>
#include <stdio.h>
#include <stdlib.h>

#define fatal_error() abort()

const char* myfile = "my_file.log";

void func(void)
{
    int c;
    FILE* fptr;
    /* getc() has stream argument fptr with
    * 2 side effects: call to fopen(), and assignment
    * of fptr
    */
    c = getc(fptr = fopen(myfile, "r"));
    if (c == EOF) {
        /* Handle error */
        (void)fclose(fptr);
        fatal_error();
    }
    if (fclose(fptr) == EOF) {
        /* Handle error */
        fatal_error();
    }
}

void main(void)
{
```

```
    func();

}
```

In this example, `getc()` is called with stream argument `fptr`. The stream argument has two side effects: the call to `fopen()` and the assignment of `fptr`. If `getc()` is implemented as an unsafe macro, the side effects happen multiple times.

Correction — Use Separate Statement for `fopen()`

One possible correction is to use a separate statement for `fopen()`. The call to `fopen()` and the assignment of `fptr` happen in this statement so there are no side effects when you pass `fptr` to `getc()`.

```
#include <stddef.h>
#include <stdio.h>
#include <stdlib.h>

#define fatal_error() abort()


const char* myfile = "my_file.log";

void func(void)
{
    int c;
    FILE* fptr;

    /* Separate statement for fopen()
    * before call to getc()
    */
    fptr = fopen(myfile, "r");
    if (fptr == NULL) {
        /* Handle error */
        fatal_error();
    }
    c = getc(fptr);
    if (c == EOF) {
        /* Handle error */
        (void)fclose(fptr);
        fatal_error();
    }
    if (fclose(fptr) == EOF) {
        /* Handle error */
```

```
        fatal_error();
    }
}

void main(void)
{
    func();

}
```

Check Information

Group: 07. Input Output (FIO)

See Also

External Websites

FIO41-C

Introduced in R2019a

CERT C++: FIO42-C

Close files when they are no longer needed

Description

Rule Definition

Close files when they are no longer needed.

Examples

Resource leak

Description

Resource leak occurs when you open a file stream by using a `FILE` pointer but do not close it before:

- The end of the pointer's scope.
- Assigning the pointer to another stream.

Risk

If you do not release file handles explicitly as soon as possible, a failure can occur due to exhaustion of resources.

Fix

Close a `FILE` pointer before the end of its scope, or before you assign the pointer to another stream.

Example - `FILE` Pointer Not Released Before End of Scope

```
#include <stdio.h>
```

```
void func1( void ) {
    FILE *fp1;
    fp1 = fopen ( "data1.txt", "w" );
    fprintf ( fp1, "*" );

    fp1 = fopen ( "data2.txt", "w" );
    fprintf ( fp1, "!" );
    fclose ( fp1 );
}
```

In this example, the file pointer `fp1` is pointing to a file `data1.txt`. Before `fp1` is explicitly dissociated from the file stream of `data1.txt`, it is used to access another file `data2.txt`.

Correction — Release `FILE` Pointer

One possible correction is to explicitly dissociate `fp1` from the file stream of `data1.txt`.

```
#include <stdio.h>

void func1( void ) {
    FILE *fp1;
    fp1 = fopen ( "data1.txt", "w" );
    fprintf ( fp1, "*" );
    fclose(fp1);

    fp1 = fopen ( "data2.txt", "w" );
    fprintf ( fp1, "!" );
    fclose ( fp1 );
}
```

Check Information

Group: 07. Input Output (FIO)

See Also

External Websites

FIO42-C

Introduced in R2019a

CERT C++: FIO44-C

Only use values for fsetpos() that are returned from fgetpos()

Description

Rule Definition

Only use values for fsetpos() that are returned from fgetpos().

Examples

Invalid file position

Description

Invalid file position occurs when the file position argument of `fsetpos()` uses a value that is not obtained from `fgetpos()`.

Risk

The function `fgetpos(FILE *stream, fpos_t *pos)` gets the current file position of the stream. When you use any other value as the file position argument of `fsetpos(FILE *stream, const fpos_t *pos)`, you might access an unintended location in the stream.

Fix

Use the value returned from a successful call to `fgetpos()` as the file position argument of `fsetpos()`.

Example - `memset()` Sets File Position Argument

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
```

```
FILE *func(FILE *file)
{
    fpos_t offset;
    if (file == NULL)
    {
        /* Handle error */
    }
    /* Store initial position in variable 'offset' */
    (void)memset(&offset, 0, sizeof(offset));

    /* Read data from file */

    /* Return to the initial position. offset was not
    returned from a call to fgetpos()    */
    if (fsetpos(file, &offset) != 0)
    {
        /* Handle error */
    }
    return file;
}
```

In this example, `fsetpos()` uses `offset` as its file position argument. However, the value of `offset` is set by `memset()`. The preceding code might access the wrong location in the stream.

Correction — Use a File Position Returned From `fgetpos()`

Call `fgetpos()`, and if it returns successfully, use the position argument in your call to `fsetpos()`.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

FILE *func(FILE *file)
{
    fpos_t offset;
    if (file == NULL)
    {
        /* Handle error */
```

```
    }
    /* Store initial position in variable 'offset'
    using fgetpos() */
    if (fgetpos(file, &offset) != 0)
    {
        /* Handle error */
    }

    /* Read data from file */

    /* Back to the initial position */
    if (fsetpos(file, &offset) != 0)
    {
        /* Handle error */
    }
    return file;
}
```

Check Information

Group: 07. Input Output (FIO)

See Also

External Websites

FIO44-C

Introduced in R2019a

CERT C++: FIO45-C

Avoid TOCTOU race conditions while accessing files

Description

Rule Definition

Avoid TOCTOU race conditions while accessing files.

Examples

File access between time of check and use (TOCTOU)

Description

File access between time of check and use (TOCTOU) detects race condition issues between checking the existence of a file or folder, and using a file or folder.

Risk

An attacker can access and manipulate your file between your check for the file and your use of a file. Symbolic links are particularly risky because an attacker can change where your symbolic link points.

Fix

Before using a file, do not check its status. Instead, use the file and check the results afterward.

Example - Check File Before Using

```
#include <stdio.h>
#include <fcntl.h>
#include <unistd.h>
```

```
extern void print_tofile(FILE* f);

void toctou(char * log_path) {
    if (access(log_path, W_OK)==0) {
        FILE* f = fopen(log_path, "w");
        if (f) {
            print_tofile(f);
            fclose(f);
        }
    }
}
```

In this example, before opening and using the file, the function checks if the file exists. However, an attacker can change the file between the first and second lines of the function.

Correction — Open Then Check

One possible correction is to open the file, and then check the existence and contents afterward.

```
#include <stdio.h>
#include <fcntl.h>
#include <unistd.h>

extern void print_tofile(FILE* f);

void toctou(char * log_path) {
    int fd = open(log_path, O_WRONLY);
    if (fd!=-1) {
        FILE *f = fdopen(fd, "w");
        if (f) {
            print_tofile(f);
            fclose(f);
        }
    }
}
```

Check Information

Group: 07. Input Output (FIO)

See Also

External Websites

FIO45-C

Introduced in R2019a

CERT C++: FIO46-C

Do not access a closed file

Description

Rule Definition

Do not access a closed file.

Examples

Use of previously closed resource

Description

Use of previously closed resource occurs when a function operates on a stream that you closed earlier in your code.

Risk

The standard states that the value of a `FILE*` pointer is indeterminate after you close the stream associated with it. Operations using the `FILE*` pointer can produce unintended results.

Fix

One possible fix is to close the stream only at the end of operations. Another fix is to reopen the stream before using it again.

Example - Use of `FILE*` Pointer After Closing Stream

```
#include <stdio.h>

void func(void) {
    FILE *fp;
```

```
    void *ptr;

    fp = fopen("tmp","w");
    if(fp != NULL) {
        fclose(fp);
        fprintf(fp,"text");
    }
}
```

In this example, `fclose` closes the stream associated with `fp`. When you use `fprintf` on `fp` after `fclose`, the **Use of previously closed resource** defect appears.

Correction — Close Stream After All Operations

One possible correction is to reverse the order of the `fprintf` and `fclose` operations.

```
#include <stdio.h>

void func(void) {
    FILE *fp;
    void *ptr;

    fp = fopen("tmp","w");
    if(fp != NULL) {
        fprintf(fp,"text");
        fclose(fp);
    }
}
```

Check Information

Group: 07. Input Output (FIO)

See Also

External Websites

FIO46-C

Introduced in R2019a

CERT C++: FIO47-C

Use valid format strings

Description

Rule Definition

Use valid format strings.

Examples

Format string specifiers and arguments mismatch

Description

Format string specifiers and arguments mismatch occurs when the format specifiers in the formatted output functions such as `printf` do not match their corresponding arguments. For example, an argument of type `unsigned long` must have a format specification of `%lu`.

Risk

Mismatch between format specifiers and the corresponding arguments result in undefined behavior.

Fix

Make sure that the format specifiers match the corresponding arguments. For instance, in this example, the `%d` specifier does not match the string argument `message` and the `%s` specifier does not match the integer argument `err_number`.

```
const char *message = "License not available";
int err_number = ;-4
printf("Error: %d (error type %s)\n", message, err_number);
```

Switching the two format specifiers fixes the issue. See the specifications for the printf function for more information about format specifiers.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Printing a Float

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;

    printf("%d\n", fst);
}
```

In the `printf` statement, the format specifier, `%d`, does not match the data type of `fst`.

Correction — Use an Unsigned Long Format Specifier

One possible correction is to use the `%lu` format specifier. This specifier matches the `unsigned` integer type and `long` size of `fst`.

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;

    printf("%lu\n", fst);
}
```

Correction — Use an Integer Argument

One possible correction is to change the argument to match the format specifier. Convert `fst` to an integer to match the format specifier and print the value `1`.

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;
```

```
    printf("%d\n", (int)fst);
}
```

Check Information

Group: 07. Input Output (FIO)

See Also

External Websites

FIO47-C

Introduced in R2019a

CERT C++: FIO50-CPP

Do not alternately input and output from a file stream without an intervening positioning call

Description

Rule Definition

Do not alternately input and output from a file stream without an intervening positioning call.

Examples

Alternating input and output from a stream without flush or positioning call

Description

Alternating input and output from a stream without flush or positioning call occurs when:

- You do not perform a flush or function positioning call between an output operation and a following input operation on a file stream in update mode.
- You do not perform a function positioning call between an input operation and a following output operation on a file stream in update mode.

Risk

Alternating input and output operations on a stream without an intervening flush or positioning call is undefined behavior.

Fix

Call `fflush()` or a file positioning function such as `fseek()` or `fsetpos()` between output and input operations on an update stream.

Call a file positioning function between input and output operations on an update stream.

Example - Read After Write Without Intervening Flush

```
#include <stdio.h>
#define SIZE20 20

void initialize_data(char* data, size_t s) {};
const char *temp_filename = "/tmp/demo.txt";

void func()
{
    char data[SIZE20];
    char append_data[SIZE20];
    FILE *file;

    file = fopen(temp_filename, "a+");
    if (file == NULL)
      {
        /* Handle error. */;
      }

    initialize_data(append_data, SIZE20);

    if (fwrite(append_data, 1, SIZE20, file) != SIZE20)
      {
        (void)fclose(file);
        /* Handle error. */;
      }
    /* Read operation after write without
    intervening flush. */
    if (fread(data, 1, SIZE20, file) < SIZE20)
      {
          (void)fclose(file);
          /* Handle error. */;
      }

    if (fclose(file) == EOF)
      {
        /* Handle error. */;
      }
}
```

In this example, the file `demo.txt` is opened for reading and appending. After the call to `fwrite()`, a call to `fread()` without an intervening flush operation is undefined behavior.

Correction — Call `fflush()` Before the Read Operation

After writing data to the file, before calling `fread()`, perform a flush call.

```
#include <stdio.h>
#define SIZE20 20

void initialize_data(char* data, size_t s) {};
const char *temp_filename = "/tmp/demo.txt";


void func()
{
    char data[SIZE20];
    char append_data[SIZE20];
    FILE *file;

    file = fopen(temp_filename, "a+");
    if (file == NULL)
      {
        /* Handle error. */;
      }

    initialize_data(append_data, SIZE20);

    if (fwrite(append_data, 1, SIZE20, file) != SIZE20)
      {
        (void)fclose(file);
        /* Handle error. */;
      }
    /* Buffer flush after write and before read */
    if (fflush(file) != 0)
      {
        (void)fclose(file);
        /* Handle error. */;
      }
    if (fread(data, 1, SIZE20, file) < SIZE20)
      {
        (void)fclose(file);
        /* Handle error. */;
```

```
      }

    if (fclose(file) == EOF)
      {
        /* Handle error. */;
      }
}
```

Check Information

Group: 07. Input Output (FIO)

See Also

External Websites

FIO50-CPP

Introduced in R2019a

CERT C++: FIO51-CPP

Close files when they are no longer needed

Description

Rule Definition

Close files when they are no longer needed.

Examples

Resource leak

Description

Resource leak occurs when you open a file stream by using a `FILE` pointer but do not close it before:

- The end of the pointer's scope.
- Assigning the pointer to another stream.

Risk

If you do not release file handles explicitly as soon as possible, a failure can occur due to exhaustion of resources.

Fix

Close a `FILE` pointer before the end of its scope, or before you assign the pointer to another stream.

Example - `FILE` Pointer Not Released Before End of Scope

```
#include <stdio.h>
```

```
void func1( void ) {
    FILE *fp1;
    fp1 = fopen ( "data1.txt", "w" );
    fprintf ( fp1, "*" );

    fp1 = fopen ( "data2.txt", "w" );
    fprintf ( fp1, "!" );
    fclose ( fp1 );
}
```

In this example, the file pointer `fp1` is pointing to a file `data1.txt`. Before `fp1` is explicitly dissociated from the file stream of `data1.txt`, it is used to access another file `data2.txt`.

Correction — Release `FILE` Pointer

One possible correction is to explicitly dissociate `fp1` from the file stream of `data1.txt`.

```
#include <stdio.h>

void func1( void ) {
    FILE *fp1;
    fp1 = fopen ( "data1.txt", "w" );
    fprintf ( fp1, "*" );
    fclose(fp1);

    fp1 = fopen ( "data2.txt", "w" );
    fprintf ( fp1, "!" );
    fclose ( fp1 );
}
```

Check Information

Group: 07. Input Output (FIO)

See Also

External Websites

FIO51-CPP

Introduced in R2019a

08. Exceptions and Error Handling (ERR))

CERT C++: ERR30-C

Set errno to zero before calling a library function known to set errno, and check errno only after the function returns a value indicating failure

Description

Rule Definition

Set errno to zero before calling a library function known to set errno, and check errno only after the function returns a value indicating failure.

Examples

Misuse of errno

Description

Misuse of errno occurs when you check `errno` for error conditions in situations where checking `errno` does not guarantee the absence of errors. In some cases, checking `errno` can lead to false positives.

For instance, you check `errno` following calls to the functions:

- `fopen`: If you follow the ISO Standard, the function might not set `errno` on errors.
- `atof`: If you follow the ISO Standard, the function does not set `errno`.
- `signal`: The `errno` value indicates an error only if the function returns the `SIG_ERR` error indicator.

Risk

The ISO C Standard does not enforce that these functions set `errno` on errors. Whether the functions set `errno` or not is implementation-dependent.

To detect errors, if you check `errno` alone, the validity of this check also becomes implementation-dependent.

In some cases, the `errno` value indicates an error only if the function returns a specific error indicator. If you check `errno` before checking the function return value, you can see false positives.

Fix

For information on how to detect errors, see the documentation for that specific function.

Typically, the functions return an out-of-band error indicator to indicate errors. For instance:

- `fopen` returns a null pointer if an error occurs.
- `signal` returns the `SIG_ERR` error indicator and sets `errno` to a positive value. Check `errno` only after you have checked the function return value.

Example - Incorrectly Checking for `errno` After `fopen` Call

```
#include <stdio.h>
#include <stdlib.h>
#include <errno.h>

#define fatal_error() abort()

const char *temp_filename = "/tmp/demo.txt";

FILE *func()
{
    FILE *fileptr;
    errno = 0;
    fileptr = fopen(temp_filename, "w+b");
    if (errno != 0) {
        if (fileptr != NULL) {
            (void)fclose(fileptr);
        }
        /* Handle error */
        fatal_error();
    }
    return fileptr;
}
```

In this example, `errno` is the first variable that is checked after a call to `fopen`. You might expect that `fopen` changes `errno` to a nonzero value if an error occurs. If you run this code with an implementation of `fopen` that does not set `errno` on errors, you might

miss an error condition. In this situation, `fopen` can return a null pointer that escapes detection.

Correction — Check Return Value of `fopen` After Call

One possible correction is to only check the return value of `fopen` for a null pointer.

```
#include <stdio.h>
#include <stdlib.h>
#include <errno.h>

#define fatal_error() abort()

const char *temp_filename = "/tmp/demo.txt";

FILE *func()
{
    FILE *fileptr;
    fileptr = fopen(temp_filename, "w+b");
    if (fileptr == NULL) {
        fatal_error();
    }
    return fileptr;
}
```

Errno not reset

Description

Errno not reset occurs when you do not reset `errno` before calling a function that sets `errno` to indicate error conditions. However, you check `errno` for those error conditions after the function call.

Risk

The `errno` is not clean and can contain values from a previous call. Checking `errno` for errors can give the false impression that an error occurred.

`errno` is set to zero at program startup but subsequently, `errno` is not reset by a C standard library function. You must explicitly set `errno` to zero when required.

Fix

Before calling a function that sets `errno` to indicate error conditions, reset `errno` to zero explicitly.

Example - `errno` Not Reset Before Call to `strtod`

```
#include <stdio.h>
#include <stdlib.h>
#include <errno.h>
#include <float.h>

#define fatal_error() abort()

double func(const char *s1, const char *s2)
{
    double f1;
    f1 = strtod (s1, NULL);
    if (0 == errno) {
      double f2 = strtod (s2, NULL);
        if (0 == errno) {
            long double result = (long double)f1 + f2;
            if ((result <= (long double)DBL_MAX) && (result >= (long double)-DBL_MAX))
                  {
                return (double)result;
            }
        }
    }
    fatal_error();
    return 0.0;
}
```

In this example, `errno` is not reset to 0 before the first call to `strtod`. Checking `errno` for 0 later can lead to a false positive.

Correction — Reset `errno` Before Call

One possible correction is to reset `errno` to 0 before calling `strtod`.

```
#include <stdio.h>
#include <stdlib.h>
#include <errno.h>
#include <float.h>
```

```
#define fatal_error() abort()

double func(const char *s1, const char *s2)
{
    double f1;
    errno = 0;
    f1 = strtod (s1, NULL);
    if (0 == errno) {
      double f2 = strtod (s2, NULL);
        if (0 == errno) {
            long double result = (long double)f1 + f2;
            if ((result <= (long double)DBL_MAX) && (result >= (long double)-DBL_MAX))
              {
                return (double)result;
            }
        }
    }
    fatal_error();
    return 0.0;
}
```

Check Information

Group: 08. Exceptions and Error Handling (ERR)

See Also

External Websites

ERR30-C

Introduced in R2019a

CERT C++: ERR32-C

Do not rely on indeterminate values of errno

Description

Rule Definition

Do not rely on indeterminate values of errno.

Examples

Misuse of errno in a signal handler

Description

Misuse of errno in a signal handler occurs when you call one of these functions in a signal handler:

- `signal`: You call the `signal` function in a signal handler and then read the value of `errno`.

  For instance, the signal handler function `handler` calls `signal` and then calls `perror`, which reads `errno`.

  ```
  void handler(int signum) {
    pfv old_handler = signal(signum, SIG_DFL);
    if (old_handler == SIG_ERR) {
      perror("SIGINT handler");
    }
  }
  ```

- `errno`-setting POSIX function: You call an `errno`-setting POSIX function in a signal handler but do not restore `errno` when returning from the signal handler.

  For instance, the signal handler function `handler` calls `waitpid`, which changes `errno`, but does not restore `errno` before returning.

```
void handler(int signum) {
  int rc = waitpid(-1, NULL, WNOHANG);
  if (ECHILD != errno) {
  }
}
```

Risk

In each case that the checker flags, you risk relying on an indeterminate value of `errno`.

- `signal`: If the call to `signal` in a signal handler fails, the value of `errno` is indeterminate (see C11 Standard, Sec. 7.14.1.1). If you rely on a specific value of `errno`, you can see unexpected results.
- `errno`-setting POSIX function: An `errno`-setting function sets `errno` on failure. If you read `errno` after a signal handler is called and the signal handler itself calls an `errno`-setting function, you can see unexpected results.

Fix

Avoid situations where you risk relying on an indeterminate value of `errno`.

- `signal`: After calling the `signal` function in a signal handler, do not read `errno` or use a function that reads `errno`.
- `errno`-setting POSIX function: Before calling an `errno`-setting function in a signal handler, save `errno` to a temporary variable. Restore `errno` from this variable before returning from the signal handler.

Example - Reading `errno` After `signal` Call in Signal Handler

```
#include <signal.h>
#include <stdlib.h>
#include <stdio.h>

#define fatal_error() abort()

void handler(int signum) {
    if (signal(signum, SIG_DFL) == SIG_ERR) {
        perror("SIGINT handler");
    }
}

int func(void) {
    if (signal(SIGINT, handler) == SIG_ERR) {
```

```
        /* Handle error */
        fatal_error();
    }
    /* Program code */
    if (raise(SIGINT) != 0) {
        /* Handle error */
        fatal_error();
    }
    return 0;
}
```

In this example, the function `handler` is called to handle the `SIGINT` signal. In the body of `handler`, the `signal` function is called. Following this call, the value of `errno` is indeterminate. The checker raises a defect when the `perror` function is called because `perror` relies on the value of `errno`.

Correction — Avoid Reading `errno` After `signal` Call

One possible correction is to not read `errno` after calling the `signal` function in a signal handler. The corrected code here calls the `abort` function via the `fatal_error` macro instead of the `perror` function.

```
#include <signal.h>
#include <stdlib.h>
#include <stdio.h>

#define fatal_error() abort()

void handler(int signum) {
    if (signal(signum, SIG_DFL) == SIG_ERR) {
        fatal_error();
    }
}

int func(void) {
    if (signal(SIGINT, handler) == SIG_ERR) {
        /* Handle error */
        fatal_error();
    }
    /* Program code */
    if (raise(SIGINT) != 0) {
        /* Handle error */
        fatal_error();
    }
```

```
    return 0;
}
```

Check Information

Group: 08. Exceptions and Error Handling (ERR)

See Also

External Websites

ERR32-C

Introduced in R2019a

CERT C++: ERR33-C

Detect and handle standard library errors

Description

Rule Definition

Detect and handle standard library errors.

Examples

Errno not checked

Description

Errno not checked occurs when you call a function that sets `errno` to indicate error conditions, but do not check `errno` after the call. For these functions, checking `errno` is the only reliable way to determine if an error occurred.

Functions that set `errno` on errors include:

- `fgetwc`, `strtol`, and `wcstol`.

  For a comprehensive list of functions, see documentation about errno.
- POSIX `errno`-setting functions such as `encrypt` and `setkey`.

Risk

To see if the function call completed without errors, check `errno` for error values.

The return values of these `errno`-setting functions do not indicate errors. The return value can be one of the following:

- `void`

- Even if an error occurs, the return value can be the same as the value from a successful call. Such return values are called in-band error indicators.

You can determine if an error occurred only by checking `errno`.

For instance, `strtol` converts a string to a long integer and returns the integer. If the result of conversion overflows, the function returns `LONG_MAX` and sets `errno` to `ERANGE`. However, the function can also return `LONG_MAX` from a successful conversion. Only by checking `errno` can you distinguish between an error and a successful conversion.

Fix

Before calling the function, set `errno` to zero.

After the function call, to see if an error occurred, compare `errno` to zero. Alternatively, compare `errno` to known error indicator values. For instance, `strtol` sets `errno` to `ERANGE` to indicate errors.

The error message in the Polyspace result shows the error indicator value that you can compare to.

Example - `errno` Not Checked After Call to `strtol`

```
#include<stdio.h>
#include<stdlib.h>
#include<errno.h>

int main(int argc, char *argv[]) {
    char *str, *endptr;
    int base;

    str = argv[1];
    base = 10;

    long val = strtol(str, &endptr, base);
    printf("Return value of strtol() = %ld\n", val);
}
```

You are using the return value of `strtol` without checking `errno`.

Correction — Check `errno` After Call

Before calling `strtol`, set `errno` to zero . After a call to `strtol`, check the return value for `LONG_MIN` or `LONG_MAX` and `errno` for `ERANGE`.

```
#include<stdlib.h>
#include<stdio.h>
#include<errno.h>
#include<limits.h>

int main(int argc, char *argv[]) {
    char *str, *endptr;
    int base;

    str = argv[1];
    base = 10;

    errno = 0;
    long val = strtol(str, &endptr, base);
    if((val == LONG_MIN || val == LONG_MAX) && errno == ERANGE) {
         printf("strtol error");
         exit(EXIT_FAILURE);
    }
    printf("Return value of strtol() = %ld\n", val);
}
```

Returned value of a sensitive function not checked

Description

Returned value of a sensitive function not checked occurs when you call sensitive standard functions, but you:

- Ignore the return value.
- Use an output or a return value without testing the validity of the return value.

For this defect, two type of functions are considered: ***sensitive*** and ***critical sensitive***.

A ***sensitive*** function is a standard function that can encounter:

- Exhausted system resources (for example, when allocating resources)
- Changed privileges or permissions
- Tainted sources when reading, writing, or converting data from external sources
- Unsupported features despite an existing API

A ***critical sensitive*** function is a sensitive function that performs one of these critical or vulnerable tasks:

- Set privileges (for example, `setuid`)
- Create a jail (for example, `chroot`)
- Create a process (for example, `fork`)
- Create a thread (for example, `pthread_create`)
- Lock or unlock mutex (for example, `pthread_mutex_lock`)
- Lock or unlock memory segments (for example, `mlock`)

Risk

If you do not check the return value of functions that perform sensitive or critical sensitive tasks, your program can behave unexpectedly. Errors from these functions can propagate throughout the program causing incorrect output, security vulnerabilities, and possibly system failures.

Fix

Before continuing with the program, test the return value of *critical sensitive* functions.

For *sensitive functions*, you can explicitly ignore a return value by casting the function to `void`. Polyspace does not raise this defect for sensitive functions cast to void. This resolution is not accepted for *critical sensitive functions* because they perform more vulnerable tasks.

Example - Sensitive Function Return Ignored

```
#include <pthread.h>

void initialize() {
    pthread_attr_t attr;

    pthread_attr_init(&attr);
}
```

This example shows a call to the sensitive function `pthread_attr_init`. The return value of `pthread_attr_init` is ignored, causing a defect.

Correction — Cast Function to `(void)`

One possible correction is to cast the function to void. This fix informs Polyspace and any reviewers that you are explicitly ignoring the return value of the sensitive function.

```
#include <pthread.h>

void initialize() {
    pthread_attr_t attr;

    (void)pthread_attr_init(&attr);
}
```

Correction — Test Return Value

One possible correction is to test the return value of `pthread_attr_init` to check for errors.

```
#include <pthread.h>
#include <stdlib.h>
#define fatal_error() abort()

void initialize() {
    pthread_attr_t attr;
    int result;

    result = pthread_attr_init(&attr);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }
}
```

Example - Critical Function Return Ignored

```
#include <pthread.h>
extern void *start_routine(void *);

void returnnotchecked() {
    pthread_t thread_id;
    pthread_attr_t attr;
    void *res;

    (void)pthread_attr_init(&attr);
    (void)pthread_create(&thread_id, &attr, &start_routine, ((void *)0));
    pthread_join(thread_id,  &res);
}
```

In this example, two critical functions are called: `pthread_create` and `pthread_join`. The return value of the `pthread_create` is ignored by casting to void, but because

`pthread_create` is a critical function (not just a sensitive function), Polyspace does not ignore this *Return value of a sensitive function not checked* defect. The other critical function, `pthread_join`, returns value that is ignored implicitly. `pthread_join` uses the return value of `pthread_create`, which was not checked.

Correction — Test the Return Value of Critical Functions

The correction for this defect is to check the return value of these critical functions to verify the function performed as expected.

```
#include <pthread.h>
#include <stdlib.h>
#define fatal_error() abort()

extern void *start_routine(void *);

void returnnotchecked() {
    pthread_t thread_id;
    pthread_attr_t attr;
    void *res;
    int result;

    (void)pthread_attr_init(&attr);
    result = pthread_create(&thread_id, &attr, &start_routine, NULL);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }

    result = pthread_join(thread_id,  &res);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }
}
```

Unprotected dynamic memory allocation

Description

Unprotected dynamic memory allocation occurs when you do not check after dynamic memory allocation whether the memory allocation succeeded.

Risk

When memory is dynamically allocated using `malloc`, `calloc`, or `realloc`, it returns a value `NULL` if the requested memory is not available. If the code following the allocation accesses the memory block without checking for this `NULL` value, this access is not protected from failures.

Fix

Check the return value of `malloc`, `calloc`, or `realloc` for NULL before accessing the allocated memory location.

```
int *ptr = malloc(size * sizeof(int));

if(ptr) /* Check for NULL */
{
   /* Memory access through ptr */
}
```

Example - Unprotected dynamic memory allocation error

```
#include <stdlib.h>

void Assign_Value(void)
{
  int* p = (int*)calloc(5, sizeof(int));

  *p = 2;
  /* Defect: p is not checked for NULL value */

  free(p);
}
```

If the memory allocation fails, the function `calloc` returns `NULL` to `p`. Before accessing the memory through `p`, the code does not check whether `p` is `NULL`

Correction — Check for NULL Value

One possible correction is to check whether `p` has value `NULL` before dereference.

```
#include <stdlib.h>

void Assign_Value(void)
 {
```

```
  int* p = (int*)calloc(5, sizeof(int));

  /* Fix: Check if p is NULL */
  if(p!=NULL) *p = 2;

  free(p);
}
```

Check Information

Group: 08. Exceptions and Error Handling (ERR)

See Also

External Websites

ERR33-C

Introduced in R2019a

CERT C++: ERR34-C

Detect errors when converting a string to a number

Description

Rule Definition

Detect errors when converting a string to a number.

Examples

Unsafe conversion from string to numerical value

Description

Unsafe conversion from string to numerical value detects conversions from strings to integer or floating-point values. If your conversion method does not include robust error handling, a defect is raised.

Risk

Converting a string to numerical value can cause data loss or misinterpretation. Without validation of the conversion or error handling, your program continues with invalid values.

Fix

- Add additional checks to validate the numerical value.
- Use a more robust string-to-numeric conversion function such as `strtol`, `strtoll`, `strtoul`, or `strtoull`.

Example - Conversion With `atoi`

```
#include <stdio.h>
#include <stdlib.h>
```

```
#include <string.h>

static int demo_check_string_not_empty(char *s)
{
    if (s != NULL)
        return strlen(s) > 0; /* check string null-terminated and not empty */
    else
        return 0;
}

int unsafestrtonumeric(char* argv1)
{
    int s = 0;
    if (demo_check_string_not_empty(argv1))
    {
        s = atoi(argv1);
    }
    return s;
}
```

In this example, `argv1` is converted to an integer with `atoi`. `atoi` does not provide errors for an invalid integer string. The conversion can fail unexpectedly.

Correction — Use `strtol` instead

One possible correction is to use `strtol` to validate the input string and the converted integer.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <limits.h>
#include <errno.h>

static int demo_check_string_not_empty(char *s)
{
    if (s != NULL)
        return strlen(s) > 0; /* check string null-terminated and not empty */
    else
        return 0;
}

int unsafestrtonumeric(char *argv1)
{
    char *c_str = argv1;
```

```
    char *end;
    long sl;

    if (demo_check_string_not_empty(c_str))
    {
        errno = 0; /* set errno for error check */
        sl = strtol(c_str, &end, 10);
        if (end == c_str)
        {
            (void)fprintf(stderr, "%s: not a decimal number\n", c_str);
        }
        else if ('\0' != *end)
        {
            (void)fprintf(stderr, "%s: extra characters: %s\n", c_str, end);
        }
        else if ((LONG_MIN == sl || LONG_MAX == sl) && ERANGE == errno)
        {
            (void)fprintf(stderr, "%s out of range of type long\n", c_str);
        }
        else if (sl > INT_MAX)
        {
            (void)fprintf(stderr, "%ld greater than INT_MAX\n", sl);
        }
        else if (sl < INT_MIN)
        {
            (void)fprintf(stderr, "%ld less than INT_MIN\n", sl);
        }
        else
        {
            return (int)sl;
        }
    }
    return 0;
}
```

Check Information

Group: 08. Exceptions and Error Handling (ERR)

See Also

External Websites

ERR34-C

Introduced in R2019a

CERT C++: ERR50-CPP

Do not abruptly terminate the program

Description

Rule Definition

Do not abruptly terminate the program.

Examples

Implicit call to terminate() function

Description

The checker flags these situations when the terminate() function can be called implicitly:

- An exception escapes uncaught. For instance:
  - Before an exception is caught, it escapes through another function that throws an uncaught exception. For instance, a catch statement or exception handler invokes a copy constructor that throws an uncaught exception.
  - A throw expression with no operand rethrows an uncaught exception.
- A class destructor throws an exception.

Check Information

Group: 08. Exceptions and Error Handling (ERR)

See Also

External Websites

ERR50-CPP

Introduced in R2019a

CERT C++: ERR51-CPP

Handle all exceptions

Description

Rule Definition

Handle all exceptions.

Examples

Unhandled exception not caught

Description

The checker shows a violation if there is no `try`/`catch` in the `main` function or the `catch` does not handle all exceptions (with ellipsis `...`). The rule is not checked if a `main` function does not exist.

The checker does not determine if an exception of an unhandled type actually propagates to `main`.

Bug Finder and Code Prover check this coding rule differently. The analyses can produce different results.

Check Information

Group: 08. Exceptions and Error Handling (ERR)

See Also

External Websites

ERR51-CPP

Introduced in R2019a

CERT C++: ERR52-CPP

Do not use setjmp() or longjmp()

Description

Rule Definition

Do not use setjmp() or longjmp().

Examples

Use of setjmp/longjmp

Description

Use of setjmp/longjmp occurs when you use a combination of `setjmp` and `longjmp` or `sigsetjmp` and `siglongjmp` to deviate from normal control flow and perform non-local jumps in your code.

Risk

Using `setjmp` and `longjmp`, or `sigsetjmp` and `siglongjmp` has the following risks:

- Nonlocal jumps are vulnerable to attacks that exploit common errors such as buffer overflows. Attackers can redirect the control flow and potentially execute arbitrary code.
- Resources such as dynamically allocated memory and open files might not be closed, causing resource leaks.
- If you use `setjmp` and `longjmp` in combination with a signal handler, unexpected control flow can occur. POSIX does not specify whether `setjmp` saves the signal mask.
- Using `setjmp` and `longjmp` or `sigsetjmp` and `siglongjmp` makes your program difficult to understand and maintain.

Fix

Perform nonlocal jumps in your code using `setjmp/longjmp` or `sigsetjmp/siglongjmp` only in contexts where such jumps can be performed securely. Alternatively, use POSIX threads if possible.

In C++, to simulate throwing and catching exceptions, use standard idioms such as `throw` expressions and `catch` statements.

Example - Use of `setjmp` and `longjmp`

```
#include <setjmp.h>
#include <signal.h>

extern int update(int);
extern void print_int(int);

static jmp_buf env;
void sighandler(int signum) {
    longjmp(env, signum);
}
void func_main(int i) {
    signal(SIGINT, sighandler);
    if (setjmp(env)==0) {
        while(1) {
            /* Main loop of program, iterates until SIGINT signal catch */
            i = update(i);
        }
    } else {
        /* Managing longjmp return */
        i = -update(i);
    }

    print_int(i);
    return;
}
```

In this example, the initial return value of `setjmp` is 0. The `update` function is called in an infinite `while` loop until the user interrupts it through a signal.

In the signal handling function, the `longjmp` statement causes a jump back to `main` and the return value of `setjmp` is now 1. Therefore, the `else` branch is executed.

Correction — Use Alternative to `setjmp` and `longjmp`

To emulate the same behavior more securely, use a `volatile` global variable instead of a combination of `setjmp` and `longjmp`.

```
#include <setjmp.h>
#include <signal.h>

extern int update(int);
extern void print_int(int);

volatile sig_atomic_t eflag = 0;

void sighandler(int signum) {
     eflag = signum;                   /* Fix: using global variable */
}

void func_main(int i) {
      /* Fix: Better design to avoid use of setjmp/longjmp */
    signal(SIGINT, sighandler);
    while(!eflag) {                   /* Fix: using global variable */
        /* Main loop of program, iterates until eflag is changed */
        i = update(i);
    }

    print_int(i);
    return;
}
```

Check Information

Group: 08. Exceptions and Error Handling (ERR)

See Also

External Websites

ERR52-CPP

Introduced in R2019a

CERT C++: ERR53-CPP

Do not reference base classes or class data members in a constructor or destructor function-try-block handler

Description

Rule Definition

Do not reference base classes or class data members in a constructor or destructor function-try-block handler.

Examples

Constructor or destructor function-try-block handler references base classes or class data members

Description

The issue occurs when handlers of a function-try-block implementation of a class constructor or destructor references non-static members from this class or its bases.

Check Information

Group: 08. Exceptions and Error Handling (ERR)

See Also

External Websites

ERR53-CPP

Introduced in R2019a

CERT C++: ERR54-CPP

Catch handlers should order their parameter types from most derived to least derived

Description

Rule Definition

Catch handlers should order their parameter types from most derived to least derived.

Examples

Exception handlers not ordered from most-derived to base class

Description

The issue occurs when you provide multiple handlers in a single try-catch statement or function-try-block for a derived class and some or all of its bases, and the handlers are not ordered from most-derived to base class.

Incorrect order of ellipsis handler

Description

The issue occurs when you provide multiple handlers in a single try-catch statement or function-try-block, and the ellipsis (catch-all) handler does not occur last.

Check Information

Group: 08. Exceptions and Error Handling (ERR)

See Also

External Websites

ERR54-CPP

Introduced in R2019a

09. Object Oriented Programming (OOP))

CERT C++: OOP51-CPP

Do not slice derived objects

Description

Rule Definition

Do not slice derived objects.

Examples

Object slicing

Description

Object slicing occurs when you pass a derived class object by value to a function, but the function expects a base class object as parameter.

Risk

If you pass a derived class object *by value* to a function, you expect the derived class copy constructor to be called. If the function expects a base class object as parameter:

1. The base class copy constructor is called.
2. In the function body, the parameter is considered as a base class object.

In C++, `virtual` methods of a class are resolved at run time according to the actual type of the object. Because of object slicing, an incorrect implementation of a `virtual` method can be called. For instance, the base class contains a `virtual` method and the derived class contains an implementation of that method. When you call the `virtual` method from the function body, the base class method is called, even though you pass a derived class object to the function.

Fix

One possible fix is to pass the object by reference or pointer. Passing by reference or pointer does not cause invocation of copy constructors. If you do not want the object to be modified, use a `const` qualifier with your function parameter.

Another possible fix is to overload the function with another function that accepts the derived class object as parameter.

Example - Function Call Causing Object Slicing

```
#include <iostream>

class Base {
public:
    explicit Base(int b) {
        _b = b;
    }
    virtual ~Base() {}
    virtual int update() const;
protected:
    int _b;
};


class Derived: public Base {
public:
    explicit Derived(int b):Base(b) {}
    int update() const;
};

//Class methods definition

int Base::update() const {
    return (_b + 1);
}

int Derived::update() const {
    return (_b -1);
}


//Other function definitions
void funcPassByValue(const Base bObj) {
```

```
    std::cout << "Updated _b=" << bObj.update() << std::endl;
}

int main() {
    Derived dObj(0);
    funcPassByValue(dObj);       //Function call slices object
    return 0;
 }
```

In this example, the call `funcPassByValue(dObj)` results in the output `Updated _b=1` instead of the expected `Updated _b=-1`. Because `funcPassByValue` expects a `Base` object parameter, it calls the `Base` class copy constructor.

Therefore, even though you pass the `Derived` object `dObj`, the function `funcPassByValue` treats its parameter `b` as a `Base` object. It calls `Base::update()` instead of `Derived::update()`.

Correction — Pass Object by Reference or Pointer

One possible correction is to pass the `Derived` object `dObj` by reference or by pointer. In the following, corrected example, `funcPassByReference` and `funcPassByPointer` have the same objective as `funcPassByValue` in the preceding example. However, `funcPassByReference` expects a reference to a `Base` object and `funcPassByPointer` expects a pointer to a `Base` object.

Passing the `Derived` object `d` by a pointer or by reference does not slice the object. The calls `funcPassByReference(dObj)` and `funcPassByPointer(&dObj)` produce the expected result `Updated _b=-1`.

```
#include <iostream>

class Base {
public:
    explicit Base(int b) {
        _b = b;
    }
    virtual ~Base() {}
    virtual int update() const;
protected:
    int _b;
};


class Derived: public Base {
```

```
public:
    explicit Derived(int b):Base(b) {}
    int update() const;
};

//Class methods definition

int Base::update() const {
    return (_b + 1);
}

int Derived::update() const {
    return (_b -1);
}


//Other function definitions
void funcPassByReference(const Base& bRef) {
    std::cout << "Updated _b=" << bRef.update() << std::endl;
}

void funcPassByPointer(const Base* bPtr) {
    std::cout << "Updated _b=" << bPtr->update() << std::endl;
}

int main() {
    Derived dObj(0);
    funcPassByReference(dObj);       //Function call does not slice object
    funcPassByPointer(&dObj);       //Function call does not slice object
    return 0;
 }
```

Note If you pass by value, because a copy of the object is made, the original object is not modified. Passing by reference or by pointer makes the object vulnerable to modification. If you are concerned about your original object being modified, add a `const` qualifier to your function parameter, as in the preceding example.

Check Information

Group: 09. Object Oriented Programming (OOP)

See Also

External Websites

OOP51-CPP

Introduced in R2019a

CERT C++: OOP52-CPP

Do not delete a polymorphic object without a virtual destructor

Description

Rule Definition

Do not delete a polymorphic object without a virtual destructor.

Examples

Base class destructor not virtual

Description

Base class destructor not virtual occurs when a class has `virtual` functions but not a `virtual` destructor.

Risk

The presence of `virtual` functions indicates that the class is intended for use as a base class. However, if the class does not have a `virtual` destructor, it cannot behave polymorphically for deletion of derived class objects.

If a pointer to this class refers to a derived class object, and you use the pointer to delete the object, only the base class destructor is called. Additional resources allocated in the derived class are not released and can cause a resource leak.

Fix

One possible fix is to always use a `virtual` destructor in a class that contains `virtual` functions.

Example - Base Class Destructor Not Virtual

```
class Base {
        public:
```

```
                Base(): _b(0) {};
                virtual void update() {_b += 1;};
        private:
                int _b;
};

class Derived: public Base {
        public:
                Derived(): _d(0) {};
                ~Derived() {_d = 0;};
                virtual void update() {_d += 1;};
        private:
                int _d;
};
```

In this example, the class `Base` does not have a `virtual` destructor. Therefore, if a `Base*` pointer points to a `Derived` object that is allocated memory dynamically, and the `delete` operation is performed on that `Base*` pointer, the `Base` destructor is called. The memory allocated for the additional member `_d` is not released.

The defect appears on the base class definition. Following are some tips for navigating in the source code:

- To find classes derived from the base class, right-click the base class name and select **Search For All References**. Browse through each search result to find derived class definitions.
- To find if you are using a pointer or reference to a base class to point to a derived class object, right-click the base class name and select **Search For All References**. Browse through search results that start with `Base*` or `Base&` to locate pointers or references to the base class. You can then see if you are using a pointer or reference to point to a derived class object.

Correction — Make Base Class Destructor Virtual

One possible correction is to declare a `virtual` destructor for the class `Base`.

```
class Base {
        public:
                Base(): _b(0) {};
                virtual ~Base() {_b = 0;};
                virtual void update() {_b += 1;};
        private:
                int _b;
```

```
};

class Derived: public Base {
        public:
                Derived(): _d(0) {};
                ~Derived() {_d = 0;};
                virtual void update() {_d += 1;};
        private:
                int _d;
};
```

Check Information

Group: 09. Object Oriented Programming (OOP)

See Also

External Websites

OOP52-CPP

Introduced in R2019a

CERT C++: OOP54-CPP

Gracefully handle self-copy assignment

Description

Rule Definition

Gracefully handle self-copy assignment.

Examples

Self assignment not tested in operator

Description

Self assignment not tested in operator occurs when you do not test if the argument to the copy assignment operator of an object is the object itself.

Risk

Self-assignment causes unnecessary copying. Though it is unlikely that you assign an object to itself, because of aliasing, you or users of your class cannot always detect a self-assignment.

Self-assignment can cause subtle errors if a data member is a pointer and you allocate memory dynamically to the pointer. In your copy assignment operator, you typically perform these steps:

1. Deallocate the memory originally associated with the pointer.

   ```
   delete ptr;
   ```

2. Allocate new memory to the pointer. Initialize the new memory location with contents obtained from the operator argument.

   ```
    ptr = new ptrType(*(opArgument.ptr));
   ```

If the argument to the operator, `opArgument`, is the object itself, after your first step, the pointer data member in the operator argument, `opArgument.ptr`, is not associated with a memory location. `*opArgument.ptr` contains unpredictable values. Therefore, in the second step, you initialize the new memory location with unpredictable values.

Fix

Test for self-assignment in the copy assignment operator of your class. Only after the test, perform the assignments in the copy assignment operator.

Example - Missing Test for Self-Assignment

```
class MyClass1 { };
class MyClass2 {
public:
    MyClass2()                : p_(new MyClass1())      { }
    MyClass2(const MyClass2& f)   : p_(new MyClass1(*f.p_)) { }
    ~MyClass2()                {
        delete p_;
    }
    MyClass2& operator= (const MyClass2& f)
    {
        delete p_;
        p_ = new MyClass1(*f.p_);
        return *this;
    }
private:
    MyClass1* p_;
};
```

In this example, the copy assignment operator in `MyClass2` does not test for self-assignment. If the parameter `f` is the current object, after the statement `delete p_`, the memory allocated to pointer `f.p_` is also deallocated. Therefore, the statement `p_ = new MyClass1(*f.p_)` initializes the memory location that `p_` points to with unpredictable values.

Correction — Test for Self-Assignment

One possible correction is to test for self-assignment in the copy assignment operator.

```
class MyClass1 { };
class MyClass2 {
public:
    MyClass2()                : p_(new MyClass1())      { }
```

```
    MyClass2(const MyClass2& f)   : p_(new MyClass1(*f.p_)) { }
    ~MyClass2()                {
        delete p_;
    }
    MyClass2& operator= (const MyClass2& f)
    {
        if(&f != this) {
           delete p_;
           p_ = new MyClass1(*f.p_);
        }
        return *this;
    }
private:
    MyClass1* p_;
};
```

Check Information

Group: 09. Object Oriented Programming (OOP)

See Also

External Websites

OOP54-CPP

Introduced in R2019a

CERT C++: OOP58-CPP

Copy operations must not mutate the source object

Description

Rule Definition

Copy operations must not mutate the source object.

Examples

Copy operation modifying source operand

Description

Copy operation modifying source operand occurs when a copy constructor or copy assignment operator modifies a mutable data member of its source operand.

For instance, this copy constructor `A` modifies the data member `m` of its source operand `other`:

```
class A {
  mutable int m;

public:
 ...
  A(const A &other) : m(other.m) {
    other.m = 0; //Modification of source
  }
}
```

Risk

A copy operation with a copy constructor (or copy assignment operator):

```
className new_object = old_object; //Calls copy constructor of className
```

copies its source operand `old_object` to its destination operand `new_object`. After the operation, you expect the destination operand to be a copy of the unmodified source operand. If the source operand is modified during copy, this assumption is violated.

Fix

Do not modify the source operand in the copy operation.

If you are modifying the source operand in a copy constructor to implement a move operation, use a move constructor instead. Move constructors are defined in the C++11 standard and later.

Example - Copy Constructor Modifying Source

```
#include <algorithm>
#include <vector>

class A {
  mutable int m;

public:
  A() : m(0) {}
  explicit A(int m) : m(m) {}

  A(const A &other) : m(other.m) {
    other.m = 0;
  }

  A& operator=(const A &other) {
    if (&other != this) {
      m = other.m;
      other.m = 0;
    }
    return *this;
  }

  int get_m() const { return m; }
};

void f() {
  std::vector<A> v{10};
  A obj(12);
  std::fill(v.begin(), v.end(), obj);
}
```

In this example, a vector of ten objects of type `A` is created. The `std::fill` function copies an object of type `A`, which has a data member with value 12, to each of the ten objects. After this operation, you might expect that all ten objects in the vector have a data member with value 12.

However, the first copy modifies the data member of the source to the value 0. The remaining nine copies copy this value. After the `std::fill` call, the first object in the vector has a data member with value 12 and the remaining objects have data members with value 0.

Correction — Use Move Constructor for Modifying Source

Do not modify data members of the source operand in a copy constructor or copy assignment operator. If you want your class to have a move operation, use a move constructor instead of a copy constructor.

In this corrected example, the copy constructor and copy assignment operator of class `A` do not modify the data member `m`. A separate move constructor modifies the source operand.

```
#include <algorithm>
#include <vector>

class A {
  int m;

public:
  A() : m(0) {}
  explicit A(int m) : m(m) {}

  A(const A &other) : m(other.m) {}
  A(A &&other) : m(other.m) { other.m = 0; }

  A& operator=(const A &other) {
    if (&other != this) {
      m = other.m;
    }
    return *this;
  }

  //Move constructor
  A& operator=(A &&other) {
```

```
    m = other.m;
    other.m = 0;
    return *this;
  }

  int get_m() const { return m; }
};

void f() {
  std::vector<A> v{10};
  A obj(12);
  std::fill(v.begin(), v.end(), obj);
}
```

Check Information

Group: 09. Object Oriented Programming (OOP)

See Also

External Websites

OOP58-CPP

Introduced in R2019a

10. Concurrency (CON)

CERT C++: CON33-C

Avoid race conditions when using library functions

Description

Rule Definition

Avoid race conditions when using library functions.

Examples

Data race through standard library function call

Description

Data race through standard library function call occurs when:

1. Multiple tasks call the same standard library function.

   For instance, multiple tasks call the `strerror` function.
2. The calls are not protected using a common protection.

   For instance, the calls are not protected by the same critical section.

Functions flagged by this defect are not guaranteed to be reentrant. A function is reentrant if it can be interrupted and safely called again before its previous invocation completes execution. If a function is not reentrant, multiple tasks calling the function without protection can cause concurrency issues. For the list of functions that are flagged, see CON33-C: Avoid race conditions when using library functions.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**. For more information, see the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

The functions flagged by this defect are nonreentrant because their implementations can use global or static variables. When multiple tasks call the function without protection, the function call from one task can interfere with the call from another task. The two invocations of the function can concurrently access the global or static variables and cause unpredictable results.

The calls can also cause more serious security vulnerabilities, such as abnormal termination, denial-of-service attack, and data integrity violations.

Fix

To fix this defect, do one of the following:

- Use a reentrant version of the standard library function if it exists.

  For instance, instead of `strerror()`, use `strerror_r()` or `strerror_s()`. For alternatives to functions flagged by this defect, see the documentation for CON33-C.
- Protect the function calls using common critical sections or temporal exclusion.

  See `Critical section details (-critical-section-begin -critical-section-end)` and `Temporally exclusive tasks (-temporal-exclusions-file)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

  To identify existing protections that you can reuse, see the table and graphs associated with the result. The table shows each pair of conflicting calls. The **Access Protections** column shows existing protections on the calls. To see the function call sequence leading to the conflicts, click the  icon. For an example, see below.

Example - Unprotected Call to Standard Library Function from Multiple Tasks

```
#include <errno.h>
#include <stdio.h>
#include <string.h>

void begin_critical_section(void);
void end_critical_section(void);

FILE *getFilePointer(void);
```

```
void func(FILE *fp) {
  fpos_t pos;
  errno = 0;
  if (0 != fgetpos(fp, &pos)) {
    char *errmsg = strerror(errno);
    printf("Could not get the file position: %s\n", errmsg);
  }
}

void task1(void) {
    FILE* fptr1 = getFilePointer();
    func(fptr1);
}

void task2(void) {
     FILE* fptr2 = getFilePointer();
     func(fptr2);
}

void task3(void) {
     FILE* fptr3 = getFilePointer();
     begin_critical_section();
     func(fptr3);
     end_critical_section();
}
```

In this example, to emulate multitasking behavior, specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	task1 task2 task3	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section	end_critical_section

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
  -entry-points task1,task2,task3
  -critical-section-begin begin_critical_section:cs1
  -critical-section-end end_critical_section:cs1
```

In this example, the tasks, `task1`, `task2` and `task3`, call the function `func`. `func` calls the nonreentrant standard library function, `strerror`.

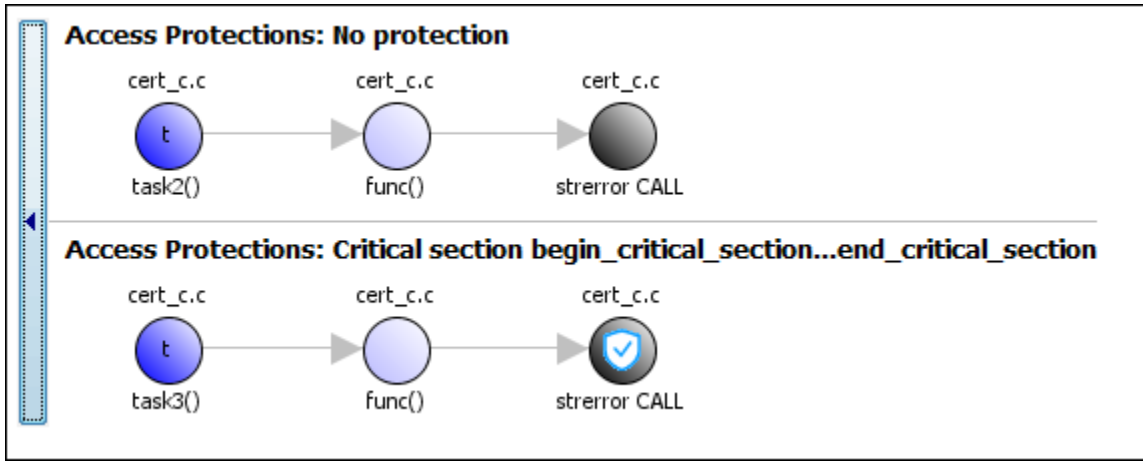
Though `task3` calls `func` inside a critical section, other tasks do not use the same critical section. Operations in the critical section of `task3` are not mutually exclusive with operations in other tasks.

These three tasks are calling a nonreentrant standard library function without common protection. In your result details, you see each pair of conflicting function calls.

! Data race through standard library function call (Impact: High)
Certain calls to function 'strerror' can interfere with each other and cause unpredictable results.
To avoid interference, calls to 'strerror' must be in the same critical section.

	Access	Access Protections	Task	File	Scope	Line
	Function call (Non atomic) Operation involves function call	No protection	task1()	data_race_std_lib.c	func()	14
	Function call (Non atomic) Operation involves function call	No protection	task2()	data_race_std_lib.c	func()	14
	Function call (Non atomic) Operation involves function call	No protection	task2()	data_race_std_lib.c	func()	14
	Function call (Non atomic) Operation involves function call	**Critical section begin_critical_section...end_critical_section**	task3()	data_race_std_lib.c	func()	14
	Function call (Non atomic) Operation involves function call	No protection	task1()	data_race_std_lib.c	func()	14
	Function call (Non atomic) Operation involves function call	**Critical section begin_critical_section...end_critical_section**	task3()	data_race_std_lib.c	func()	14

If you click the  icon, you see the function call sequence starting from the entry point to the standard library function call. You also see that the call starting from `task3` is in a critical section. The **Access Protections** entry shows the lock and unlock function that begin and end the critical section. In this example, you see the functions `begin_critical_section` and `end_critical_section`.



Correction — Use Reentrant Version of Standard Library Function

One possible correction is to use a reentrant version of the standard library function `strerror`. You can use the POSIX version `strerror_r` which has the same functionality but also guarantees thread-safety.

```
#include <errno.h>
#include <stdio.h>
#include <string.h>

void begin_critical_section(void);
void end_critical_section(void);

FILE *getFilePointer(void);
enum { BUFFERSIZE = 64 };

void func(FILE *fp) {
  fpos_t pos;
  errno = 0;
  if (0 != fgetpos(fp, &pos)) {
    char errmsg[BUFFERSIZE];
    if (strerror_r(errno, errmsg, BUFFERSIZE) != 0) {
      /* Handle error */
    }
    printf("Could not get the file position: %s\n", errmsg);
  }
```

```
}

void task1(void) {
    FILE* fptr1 = getFilePointer();
    func(fptr1);
}

void task2(void) {
     FILE* fptr2 = getFilePointer();
     func(fptr2);
}

void task3(void) {
     FILE* fptr3 = getFilePointer();
     begin_critical_section();
     func(fptr3);
     end_critical_section();
}
```

Correction — Place Function Call in Critical Section

One possible correction is to place the call to `strerror` in critical section. You can implement the critical section in multiple ways.

For instance, you can place the call to the intermediate function `func` in the same critical section in the three tasks. When `task1` enters its critical section, the other tasks cannot enter their critical sections until `task1` leaves its critical section. The calls to `func` and therefore the calls to `strerror` from the three tasks cannot interfere with each other.

To implement the critical section, in each of the three tasks, call `func` between calls to `begin_critical_section` and `end_critical_section`.

```
#include <errno.h>
#include <stdio.h>
#include <string.h>

void begin_critical_section(void);
void end_critical_section(void);

FILE *getFilePointer(void);

void func(FILE *fp) {
  fpos_t pos;
```

```
  errno = 0;
  if (0 != fgetpos(fp, &pos)) {
    char *errmsg = strerror(errno);
    printf("Could not get the file position: %s\n", errmsg);
  }
}

void task1(void) {
    FILE* fptr1 = getFilePointer();
    begin_critical_section();
    func(fptr1);
    end_critical_section();
}

void task2(void) {
     FILE* fptr2 = getFilePointer();
     begin_critical_section();
     func(fptr2);
     end_critical_section();
}

void task3(void) {
     FILE* fptr3 = getFilePointer();
     begin_critical_section();
     func(fptr3);
     end_critical_section();
}
```

Correction — Make Tasks Temporally Exclusive

Another possible correction is to make the tasks, `task1`, `task2` and `task3`, temporally exclusive. Temporally exclusive tasks cannot execute concurrently.

On the **Configuration** pane, specify the following additional options:

Option	Value
`Temporally exclusive tasks (-temporal-exclusions-file)`	`task1 task2 task3`

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
    -temporal-exclusions-file "C:\exclusions_file.txt"
```

where the file `C:\exclusions_file.txt` has the following line:

```
task1 task2 task3
```

Check Information

Group: 10. Concurrency (CON)

See Also

External Websites

CON33-C

Introduced in R2019a

CERT C++: CON37-C

Do not call signal() in a multithreaded program

Description

Rule Definition

Do not call signal() in a multithreaded program.

Examples

Signal call in multithreaded program

Description

Signal call in multithreaded program occurs when you use the `signal()` function in a program with multiple threads.

Risk

According to the C11 standard (Section 7.14.1.1), use of the `signal()` function in a multithreaded program is undefined behavior.

Fix

Depending on your intent, use other ways to perform an asynchronous action on a specific thread.

Example - Use of `signal()` Function to Terminate Loop in Thread

```
#include <signal.h>
#include <stddef.h>
#include <threads.h>

volatile sig_atomic_t flag = 0;
```

```
void handler(int signum) {
  flag = 1;
}

/* Runs until user sends SIGUSR1 */
int func(void *data) {
  while (!flag) {
    /* ... */
  }
  return 0;
}

int main(void) {
  signal(SIGINT, handler); /* Undefined behavior */
  thrd_t tid;

  if (thrd_success != thrd_create(&tid, func, NULL)) {
    /* Handle error */
  }
  /* ... */
  return 0;
}
```

In this example, the `signal` function is used to terminate a `while` loop in the thread created with `thrd_create`.

Correction — Use `atomic_bool` Variable to Terminate Loop

One possible correction is to use an `atomic_bool` variable that multiple threads can access. In the corrected example, the child thread evaluates this variable before every loop iteration. After completing the program, you can modify this variable so that the child thread exits the loop.

```
#include <stdatomic.h>
#include <stdbool.h>
#include <stddef.h>
#include <threads.h>

atomic_bool flag = ATOMIC_VAR_INIT(false);

int func(void *data) {
  while (!flag) {
    /* ... */
```

```
  }
  return 0;
}

int main(void) {
  thrd_t tid;

  if (thrd_success != thrd_create(&tid, func, NULL)) {
    /* Handle error */
  }
  /* ... */
  /* Set flag when done */
  flag = true;

  return 0;
}
```

Check Information

Group: 10. Concurrency (CON)

See Also

External Websites

CON37-C

Introduced in R2019a

CERT C++: CON40-C

Do not refer to an atomic variable twice in an expression

Description

Rule Definition

Do not refer to an atomic variable twice in an expression.

Examples

Atomic variable accessed twice in an expression

Description

Atomic variable accessed twice in an expression occurs when C atomic types or C++ `std::atomic` class variables appear twice in an expression and there are:

- Two atomic read operations on the variable.
- An atomic read and a distinct atomic write operation on the variable.

The C standard defines certain operations on atomic variables that are thread safe and do not cause data race conditions. Unlike individual operations, a pair of operations on the same atomic variable in an expression is not thread safe.

Risk

A thread can modify the atomic variable between the pair of atomic operations, which can result in a data race condition.

Fix

Do not reference an atomic variable twice in the same expression.

Example - Referencing Atomic Variable Twice in an Expression

```
#include <stdatomic.h>

atomic_int n = ATOMIC_VAR_INIT(0);

int compute_sum(void)
{
    return n * (n + 1) / 2;
}
```

In this example, the global variable `n` is referenced twice in the return statement of `compute_sum()`. The value of `n` can change between the two distinct read operations. `compute_sum()` can return an incorrect value.

Correction — Pass Variable as Function Argument

One possible correction is to pass the variable as a function argument `n`. The variable is copied to memory and the read operations on the copy guarantee that `compute_sum()` returns a correct result. If you pass a variable of type `int` instead of type `atomic_int`, the correction is still valid.

```
#include <stdatomic.h>

int compute_sum(atomic_int n)
{
    return n * (n + 1) / 2;
}
```

Atomic load and store sequence not atomic

Description

Atomic load and store sequence not atomic occurs when you use these functions to load, and then store an atomic variable.

- C functions:
  - `atomic_load()`
  - `atomic_load_explicit()`
  - `atomic_store()`

  - `atomic_store_explicit()`
- C++ functions:
  - `std::atomic_load()`
  - `std::atomic_load_explicit()`
  - `std::atomic_store()`
  - `std::atomic_store_explicit()`
  - `std::atomic::load()`
  - `std::atomic::store()`

A thread cannot interrupt an atomic load or an atomic store operation on a variable, but a thread can interrupt a store, and then load sequence.

Risk

A thread can modify a variable between the load and store operations, resulting in a data race condition.

Fix

To read, modify, and store a variable atomically, use a compound assignment operator such as `+=`, `atomic_compare_exchange()` or `atomic_fetch_*`-family functions.

Example - Loading Then Storing an Atomic Variable

```
#include <stdatomic.h>
#include <stdbool.h>

static atomic_bool flag = ATOMIC_VAR_INIT(false);

void init_flag(void)
{
    atomic_init(&flag, false);
}

void toggle_flag(void)
{
    bool temp_flag = atomic_load(&flag);
    temp_flag = !temp_flag;
    atomic_store(&flag, temp_flag);
}
```

```
bool get_flag(void)
{
    return atomic_load(&flag);
}
```

In this example, variable `flag` of type `atomic_bool` is referenced twice inside the `toggle_flag()` function. The function loads the variable, negates its value, then stores the new value back to the variable. If two threads call `toggle_flag()`, the second thread can access `flag` between the load and store operations of the first thread. `flag` can end up in an incorrect state.

Correction — Use Compound Assignment to Modify Variable

One possible correction is to use a compound assignment operator to toggle the value of `flag`. The C standard defines the operation by using ^= as atomic.

```
 #include <stdatomic.h>
#include <stdbool.h>

static atomic_bool flag = ATOMIC_VAR_INIT(false);

void toggle_flag(void)
{
    flag ^= 1;
}

bool get_flag(void)
{
    return flag;
}
```

Check Information

Group: 10. Concurrency (CON)

See Also

External Websites

CON40-C

Introduced in R2019a

CERT C++: CON41-C

Wrap functions that can fail spuriously in a loop

Description

Rule Definition

Wrap functions that can fail spuriously in a loop.

Examples

Function that can spuriously fail not wrapped in loop

Description

Function that can spuriously fail not wrapped in loop occurs when the following atomic compare and exchange functions that can fail spuriously are called from outside a loop.

- C atomic functions:
  - `atomic_compare_exchange_weak()`
  - `atomic_compare_exchange_weak_explicit()`
- C++ atomic functions:
  - `std::atomic<T>::compare_exchange_weak(T* expected, T desired)`
  - `std::atomic<T>::compare_exchange_weak_explicit(T* expected, T desired, std::memory_order succ, std::memory_order fail)`
  - `std::atomic_compare_exchange_weak(std::atomic<T>* obj, T* expected, T desired)`
  - `std::atomic_compare_exchange_weak_explicit(volatile std::atomic<T>* obj, T* expected, T desired, std::memory_order succ, std::memory_order fail)`

The functions compare the memory contents of the object representations pointed to by `obj` and `expected`. The comparison can spuriously return false even if the memory contents are equal. This spurious failure makes the functions faster on some platforms.

Risk

An atomic compare and exchange function that spuriously fails can cause unexpected results and unexpected control flow.

Fix

Wrap atomic compare and exchange functions that can spuriously fail in a loop. The loop checks the failure condition after a possible spurious failure.

Example - `atomic_compare_exchange_weak()` Not Wrapped in Loop

```
#include <stdatomic.h>

extern void reset_count(void);
atomic_int count = ATOMIC_VAR_INIT(0);

void increment_count(void)
{
    int old_count = atomic_load(&count);
    int new_count;
    new_count = old_count + 1;
    if (!atomic_compare_exchange_weak(&count, &old_count, new_count))
        reset_count();

}
```

In this example, `increment_count()` uses `atomic_compare_exchange_weak()` to compare `count` and `old_count`. If the counts are equal, `count` is incremented to `new_count`. If they are not equal, the count is reset. When `atomic_compare_exchange_weak()` fails spuriously, the count is reset unnecessarily.

Correction — Wrap `atomic_compare_exchange_weak()` in a `while` Loop

One possible correction is to wrap the call to `atomic_compare_exchange_weak()` in a `while` loop. The loop checks the failure condition after a possible spurious failure.

```
#include <stdatomic.h>

extern void reset_count(void);
```

```
atomic_int count = ATOMIC_VAR_INIT(0);

void increment_count(void)
{
    int old_count = atomic_load(&count);
    int new_count;
    new_count = old_count + 1;

    do {
        reset_count();

    } while (!atomic_compare_exchange_weak(&count, &old_count, new_count));

}
```

Check Information

Group: 10. Concurrency (CON)

See Also

External Websites

CON41-C

Introduced in R2019a

CERT C++: CON43-C

Do not allow data races in multithreaded code

Description

Rule Definition

Do not allow data races in multithreaded code.

Examples

Data race

Description

Data race occurs when:

1. Multiple tasks perform unprotected operations on a shared variable.
2. At least one task performs a write operation.
3. At least one operation is nonatomic. For data race on both atomic and nonatomic operations, see `Data race including atomic operations`.

   See the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**. For more information, see the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Data race can result in unpredictable values of the shared variable because you do not control the order of the operations in different tasks.

Data races between two write operations are more serious than data races between a write and read operation. Two write operations can interfere with each other and result in

indeterminate values. To identify write-write conflicts, use the filters on the **Detail** column of the **Results List** pane. For these conflicts, the **Detail** column shows the additional line:

```
Variable value may be altered by write-write concurrent access.
```

See “Filter and Sort Results”.

Fix

To fix this defect, protect the operations on the shared variable using critical sections, temporal exclusion or another means. See the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

To identify existing protections that you can reuse, see the table and graphs associated with the result. The table shows each pair of conflicting calls. The **Access Protections** column shows existing protections on the calls. To see the function call sequence leading to the conflicts, click the  icon. For an example, see below.

Example - Unprotected Operation on Global Variable from Multiple Tasks

```
int var;
void begin_critical_section(void);
void end_critical_section(void);

void increment(void) {
    var++;
}

void task1(void)  {
      increment();
}

void task2(void)  {
      increment();
}

void task3(void)  {
     begin_critical_section();
     increment();
```

```
     end_critical_section();
}
```

In this example, to emulate multitasking behavior, specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	task1 task2 task3	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section	end_critical_section

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
  -entry-points task1,task2,task3
  -critical-section-begin begin_critical_section:cs1
  -critical-section-end end_critical_section:cs1
```

In this example, the tasks `task1`, `task2`, and `task3` call the function `increment`. `increment` contains the operation `var++` that can involve multiple machine instructions including:

- Reading `var`.
- Writing an increased value to `var`.

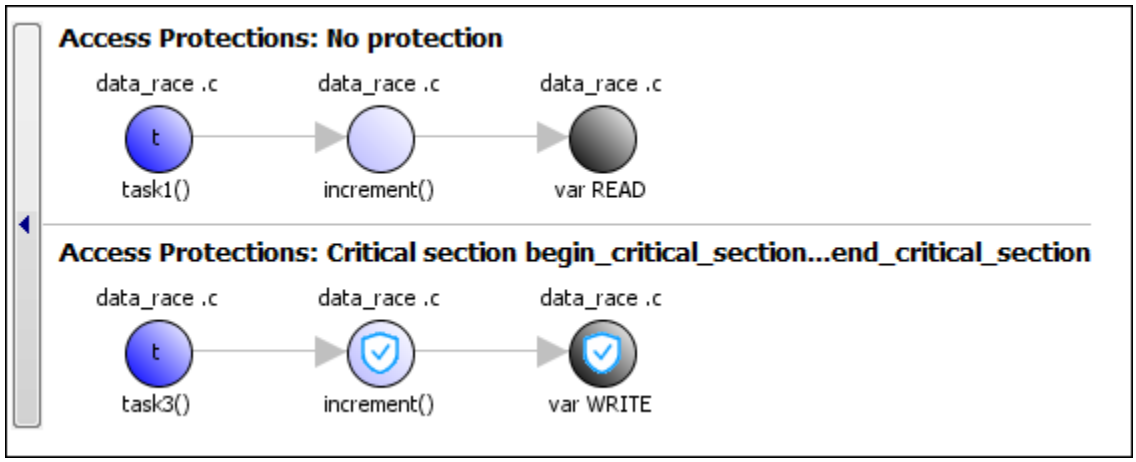
These machine instructions, when executed from `task1` and `task2`, can occur concurrently in an unpredictable sequence. For example, reading `var` from `task1` can occur either before or after writing to `var` from `task2`. Therefore the value of `var` can be unpredictable.

Though `task3` calls `increment` inside a critical section, other tasks do not use the same critical section. The operations in the critical section of `task3` are not mutually exclusive with operations in other tasks.

Therefore, the three tasks are operating on a shared variable without common protection. In your result details, you see each pair of conflicting function calls.

	Access	Access Protections	Task	File
	Read	No protection	task1()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	No protection	task2()	data_race .c
	Read	No protection	task1()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	**Critical section begin_critical_section...end_critical_section**	task3()	data_race .c
	Read	No protection	task2()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	**Critical section begin_critical_section...end_critical_section**	task3()	data_race .c

If you click the  icon, you see the function call sequence starting from the entry point to the read or write operation. You also see that the operation starting from `task3` is in a critical section. The **Access Protections** entry shows the lock and unlock function that begin and end the critical section. In this example, you see the functions `begin_critical_section` and `end_critical_section`.



Correction — Place Operation in Critical Section

One possible correction is to place the operation in critical section. You can implement the critical section in multiple ways. For instance:

- You can place `var++` in a critical section. When `task1` enters its critical section, the other tasks cannot enter their critical sections until `task1` leaves its critical section. The operation `var++` from the three tasks cannot interfere with each other.

  To implement the critical section, in the function `increment`, place the operation `var ++` between calls to `begin_critical_section` and `end_critical_section`.

```
int var;

void begin_critical_section(void);
void end_critical_section(void);

void increment(void) {
      begin_critical_section();
      var++;
      end_critical_section();
}

void task1(void)  {
      increment();
}

void task2(void)  {
      increment();
}

void task3(void)  {
      increment();
}
```

- You can place the call to `increment` in the same critical section in the three tasks. When `task1` enters its critical section, the other tasks cannot enter their critical sections until `task1` leaves its critical section. The calls to `increment` from the three tasks cannot interfere with each other.

  To implement the critical section, in each of the three tasks, call `increment` between calls to `begin_critical_section` and `end_critical_section`.

```
int var;

void begin_critical_section(void);
void end_critical_section(void);

void increment(void) {
      var++;
}

void task1(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}

void task2(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}

void task3(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}
```

Correction — Make Tasks Temporally Exclusive

Another possible correction is to make the tasks, `task1`, `task2` and `task3`, temporally exclusive. Temporally exclusive tasks cannot execute concurrently.

On the **Configuration** pane, specify the following additional options:

Option	Value
`Temporally exclusive tasks (-temporal-exclusions-file)`	`task1 task2 task3`

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
 polyspace-bug-finder
     -temporal-exclusions-file "C:\exclusions_file.txt"
```

where the file `C:\exclusions_file.txt` has the following line:

```
task1 task2 task3
```

Example - Unprotected Operation in Threads Created with `pthread_create`

```
#include <pthread.h>

pthread_mutex_t count_mutex;
long long count;


void* increment_count(void* args)
{
    count = count + 1;
    return NULL;
}

void* set_count(void *args)
{
    long long c;
    c = count;
    return NULL;
}

int main(void)
{
    pthread_t thread_increment;
    pthread_t thread_get;

    pthread_create(&thread_increment, NULL, increment_count, NULL);
    pthread_create(&thread_get, NULL, set_count, NULL);

    pthread_join(thread_get, NULL);
    pthread_join(thread_increment, NULL);

    return 1;
}
```

In this example, Bug Finder detects the creation of separate threads with `pthread_create`. The **Data race** defect is raised because the operation `count = count + 1` in the thread with id `thread_increment` conflicts with the operation `c = count` in the thread with id `thread_get`. The variable `count` is accessed in multiple threads without a common protection.

The two conflicting operations are nonatomic. The operation `c = count` is nonatomic on 32-bit targets. See the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

Correction — Protect Operations with `pthread_mutex_lock` and `pthread_mutex_unlock` Pair

To prevent concurrent access on the variable `count`, protect operations on `count` with a critical section. Use the functions `pthread_mutex_lock` and `pthread_mutex_unlock` to implement the critical section.

```
#include <pthread.h>

pthread_mutex_t count_mutex;
long long count;


void* increment_count(void* args)
{
    pthread_mutex_lock(&count_mutex);
    count = count + 1;
    pthread_mutex_unlock(&count_mutex);
    return NULL;
}

void* set_count(void *args)
{
    long long c;
    pthread_mutex_lock(&count_mutex);
    c = count;
    pthread_mutex_unlock(&count_mutex);
    return NULL;
}

int main(void)
{
    pthread_t thread_increment;
    pthread_t thread_get;
```

```
    pthread_create(&thread_increment, NULL, increment_count, NULL);
    pthread_create(&thread_get, NULL, set_count, NULL);

    pthread_join(thread_get, NULL);
    pthread_join(thread_increment, NULL);

    return 1;
}
```

Check Information

Group: 10. Concurrency (CON)

See Also

External Websites

CON43-C

Introduced in R2019a

CERT C++: CON50-CPP

Do not destroy a mutex while it is locked

Description

Rule Definition

Do not destroy a mutex while it is locked.

Examples

Destruction of locked mutex

Description

Destruction of locked mutex occurs when a task destroys a mutex after it is locked (and before it is unlocked). The locking and destruction can happen in the same task or different tasks.

Risk

A mutex is locked to protect shared variables from concurrent access. If a mutex is destroyed in the locked state, the protection does not apply.

Fix

To fix this defect, destroy the mutex only after you unlock it. It is a good design practice to:

- Initialize a mutex *before* creating the threads where you use the mutex.
- Destroy a mutex *after* joining the threads that you created.

On the **Result Details** pane, you see two events, the locking and destruction of the mutex, and the tasks that initiated the events. To navigate to the corresponding line in your source code, click the event.

Example - Locking and Destruction in Different Tasks

```
#include <pthread.h>

pthread_mutex_t lock1;
pthread_mutex_t lock2;
pthread_mutex_t lock3;

void t0 (void) {
  pthread_mutex_lock (&lock1);
  pthread_mutex_lock (&lock2);
  pthread_mutex_lock (&lock3);
  pthread_mutex_unlock (&lock2);
  pthread_mutex_unlock (&lock1);
  pthread_mutex_unlock (&lock3);
}

void t1 (void) {
  pthread_mutex_lock (&lock1);
  pthread_mutex_lock (&lock2);
  pthread_mutex_destroy (&lock3);
  pthread_mutex_unlock (&lock2);
  pthread_mutex_unlock (&lock1);
}
```

In this example, after task `t0` locks the mutex `lock3`, task `t1` can destroy it. The destruction occurs if the following events happen in sequence:

1. `t0` acquires `lock3`.
2. `t0` releases `lock2`.
3. `t0` releases `lock1`.
4. `t1` acquires the lock `lock1` released by `t0`.
5. `t1` acquires the lock `lock2` released by `t0`.
6. `t1` destroys `lock3`.

For simplicity, this example uses a mix of automatic and manual concurrency detection. The tasks `t0` and `t1` are manually specified as entry points by using the option `Tasks (-entry-points)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.The critical sections are

implemented through primitives `pthread_mutex_lock` and `pthread_mutex_unlock` that the software detects automatically. In practice, for entry point specification (thread creation), you will use primitives such as `pthread_create`. The next example shows how the defect can appear when you use `pthread_create`.

Correction — Place Lock-Unlock Pair Together in Same Critical Section as Destruction

The locking and destruction of `lock3` occurs inside the critical section imposed by `lock1` and `lock2`, but the unlocking occurs outside. One possible correction is to place the lock-unlock pair in the same critical section as the destruction of the mutex. Use one of these critical sections:

- Critical section imposed by `lock1` alone.
- Critical section imposed by `lock1` and `lock2`.

In this corrected code, the lock-unlock pair and the destruction is placed in the critical section imposed by `lock1` and `lock2`. When `t0` acquires `lock1` and `lock2`, `t1` has to wait for their release before it executes the instruction `pthread_mutex_destroy (&lock3);`. Therefore, `t1` cannot destroy mutex `lock3` in the locked state.

```
#include <pthread.h>

pthread_mutex_t lock1;
pthread_mutex_t lock2;
pthread_mutex_t lock3;

void t0 (void) {
  pthread_mutex_lock (&lock1);
  pthread_mutex_lock (&lock2);

  pthread_mutex_lock (&lock3);
  pthread_mutex_unlock (&lock3);

  pthread_mutex_unlock (&lock2);
  pthread_mutex_unlock (&lock1);
}

void t1 (void) {
  pthread_mutex_lock (&lock1);
  pthread_mutex_lock (&lock2);
```

```
  pthread_mutex_destroy (&lock3);

  pthread_mutex_unlock (&lock2);
  pthread_mutex_unlock (&lock1);
}
```

Example - Locking and Destruction in Start Routine of Thread

```
#include <pthread.h>

/* Define globally accessible variables and a mutex */
#define NUMTHREADS 4
pthread_t callThd[NUMTHREADS];
pthread_mutex_t lock;
void atomic_operation(void);

void *do_create(void *arg) {
    /* Creation thread */
    pthread_mutex_init(&lock, NULL);
    pthread_exit((void*) 0);
}

void *do_work(void *arg) {
    /* Worker thread */
    pthread_mutex_lock (&lock);
    atomic_operation();
    pthread_mutex_unlock (&lock);
    pthread_exit((void*) 0);
}

void *do_destroy(void *arg) {
    /* Destruction thread */
    pthread_mutex_destroy(&lock);
    pthread_exit((void*) 0);
}

int main (int argc, char *argv[]) {
   int i;
   void *status;
   pthread_attr_t attr;


   /* Create threads */
```

```
   pthread_attr_init(&attr);
   pthread_attr_setdetachstate(&attr, PTHREAD_CREATE_JOINABLE);

   /* Thread that initializes mutex */
   pthread_create(&callThd[0], &attr, do_create, NULL);

   /* Threads that use mutex for atomic operation*/
   for(i=0; i<NUMTHREADS-1; i++) {
      pthread_create(&callThd[i], &attr, do_work, (void *)i);
   }

   /* Thread that destroys mutex */
   pthread_create(&callThd[NUMTHREADS -1], &attr, do_destroy, NULL);

   pthread_attr_destroy(&attr);

   /* Join threads */
   for(i=0; i<NUMTHREADS; i++) {
      pthread_join(callThd[i], &status);
   }

   pthread_exit(NULL);
}
```

In this example, four threads are created. The threads are assigned different actions.

- The first thread `callThd[0]` initializes the mutex `lock`.
- The second and third threads, `callThd[1]` and `callThd[2]`, perform an atomic operation protected by the mutex `lock`.
- The fourth thread `callThd[3]` destroys the mutex `lock`.

The threads can interrupt each other. Therefore, immediately after the second or third thread locks the mutex, the fourth thread can destroy it.

Correction — Initialize and Destroy Mutex Outside Start Routine

One possible correction is to initialize and destroy the mutex in the `main` function outside the start routine of the threads. The threads perform only the atomic operation. You need two fewer threads because the mutex initialization and destruction threads are not required.

```
#include <pthread.h>
```

```
/* Define globally accessible variables and a mutex */
#define NUMTHREADS 2
pthread_t callThd[NUMTHREADS];
pthread_mutex_t lock;
void atomic_operation(void);

void *do_work(void *arg) {
   pthread_mutex_lock (&lock);
   atomic_operation();
   pthread_mutex_unlock (&lock);
   pthread_exit((void*) 0);
}

int main (int argc, char *argv[]) {
   int i;
   void *status;
   pthread_attr_t attr;


   /* Create threads */
   pthread_attr_init(&attr);
   pthread_attr_setdetachstate(&attr, PTHREAD_CREATE_JOINABLE);

   /* Initialize mutex */
   pthread_mutex_init(&lock, NULL);

   for(i=0; i<NUMTHREADS; i++) {
      pthread_create(&callThd[i], &attr, do_work, (void *)i);
   }

   pthread_attr_destroy(&attr);

   /* Join threads */
   for(i=0; i<NUMTHREADS; i++) {
      pthread_join(callThd[i], &status);
   }

   /* Destroy mutex */
   pthread_mutex_destroy(&lock);

   pthread_exit(NULL);
}
```

Correction — Use A Second Mutex To Protect Lock-Unlock Pair and Destruction

Another possible correction is to use a second mutex and protect the lock-unlock pair from the destruction. This corrected code uses the mutex `lock2` to achieve this protection. The second mutex is initialized in the `main` function outside the start routine of the threads.

```
#include <pthread.h>

/* Define globally accessible variables and a mutex */
#define NUMTHREADS 4
pthread_t callThd[NUMTHREADS];
pthread_mutex_t lock;
pthread_mutex_t lock2;
void atomic_operation(void);

void *do_create(void *arg) {
    /* Creation thread */
    pthread_mutex_init(&lock, NULL);
    pthread_exit((void*) 0);
}

void *do_work(void *arg) {
    /* Worker thread */
    pthread_mutex_lock (&lock2);
    pthread_mutex_lock (&lock);
    atomic_operation();
    pthread_mutex_unlock (&lock);
    pthread_mutex_unlock (&lock2);
    pthread_exit((void*) 0);
}

void *do_destroy(void *arg) {
    /* Destruction thread */
    pthread_mutex_lock (&lock2);
    pthread_mutex_destroy(&lock);
    pthread_mutex_unlock (&lock2);
    pthread_exit((void*) 0);
}


int main (int argc, char *argv[]) {
   int i;
   void *status;
```

```
    pthread_attr_t attr;


    /* Create threads */
    pthread_attr_init(&attr);
    pthread_attr_setdetachstate(&attr, PTHREAD_CREATE_JOINABLE);

    /* Initialize second mutex */
    pthread_mutex_init(&lock2, NULL);

    /* Thread that initializes first mutex */
    pthread_create(&callThd[0], &attr, do_create, NULL);

    /* Threads that use first mutex for atomic operation */
    /* The threads use second mutex to protect first from destruction in locked state*/
    for(i=0; i<NUMTHREADS-1; i++) {
       pthread_create(&callThd[i], &attr, do_work, (void *)i);
    }

    /* Thread that destroys first mutex */
    /* The thread uses the second mutex to prevent destruction of locked mutex */
    pthread_create(&callThd[NUMTHREADS -1], &attr, do_destroy, NULL);


    pthread_attr_destroy(&attr);

    /* Join threads */
    for(i=0; i<NUMTHREADS; i++) {
       pthread_join(callThd[i], &status);
    }

    /* Destroy second mutex */
    pthread_mutex_destroy(&lock2);

    pthread_exit(NULL);
}
```

Check Information

Group: 10. Concurrency (CON)

See Also

External Websites

CON50-CPP

Introduced in R2019a

CERT C++: CON52-CPP

Prevent data races when accessing bit-fields from multiple threads

Description

Rule Definition

Prevent data races when accessing bit-fields from multiple threads.

Examples

Data race

Description

Data race occurs when:

1. Multiple tasks perform unprotected operations on a shared variable.
2. At least one task performs a write operation.
3. At least one operation is nonatomic. For data race on both atomic and nonatomic operations, see `Data race including atomic operations`.

   See the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**. For more information, see the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Data race can result in unpredictable values of the shared variable because you do not control the order of the operations in different tasks.

Data races between two write operations are more serious than data races between a write and read operation. Two write operations can interfere with each other and result in

indeterminate values. To identify write-write conflicts, use the filters on the **Detail** column of the **Results List** pane. For these conflicts, the **Detail** column shows the additional line:

```
Variable value may be altered by write-write concurrent access.
```

See “Filter and Sort Results”.

Fix

To fix this defect, protect the operations on the shared variable using critical sections, temporal exclusion or another means. See the documentation of Polyspace Bug Finder or Polyspace Bug Finder Server.

To identify existing protections that you can reuse, see the table and graphs associated with the result. The table shows each pair of conflicting calls. The **Access Protections** column shows existing protections on the calls. To see the function call sequence leading to the conflicts, click the  icon. For an example, see below.

Example - Unprotected Operation on Global Variable from Multiple Tasks

```
int var;
void begin_critical_section(void);
void end_critical_section(void);

void increment(void) {
    var++;
}

void task1(void)  {
      increment();
}

void task2(void)  {
      increment();
}

void task3(void)  {
     begin_critical_section();
     increment();
```

```
     end_critical_section();
}
```

In this example, to emulate multitasking behavior, specify the following options:

Option	Specification	
Configure multitasking manually	☑	
Tasks (-entry-points)	task1 task2 task3	
Critical section details (-critical-section-begin -critical-section-end)	**Starting routine**	**Ending routine**
	begin_critical_section	end_critical_section

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
polyspace-bug-finder
  -entry-points task1,task2,task3
  -critical-section-begin begin_critical_section:cs1
  -critical-section-end end_critical_section:cs1
```

In this example, the tasks `task1`, `task2`, and `task3` call the function `increment`. `increment` contains the operation `var++` that can involve multiple machine instructions including:

- Reading `var`.
- Writing an increased value to `var`.

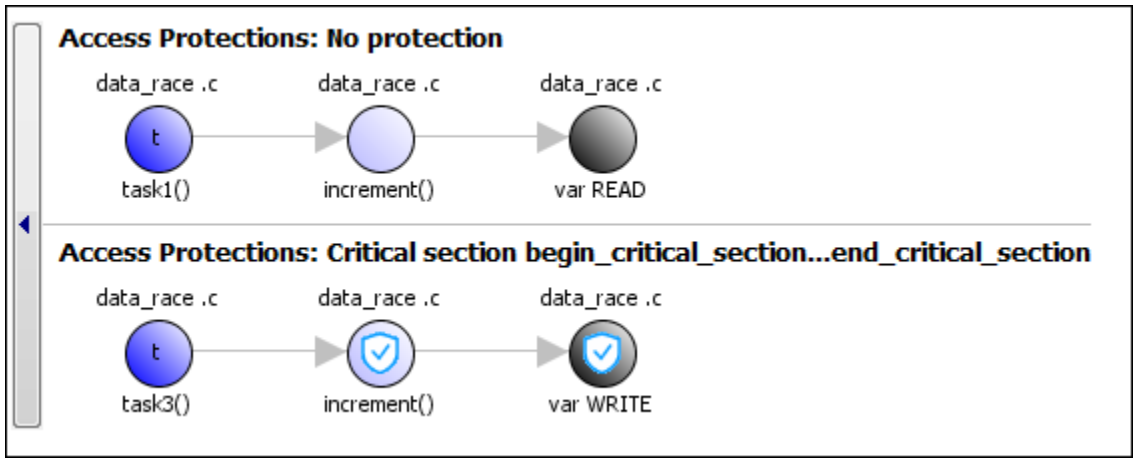
These machine instructions, when executed from `task1` and `task2`, can occur concurrently in an unpredictable sequence. For example, reading `var` from `task1` can occur either before or after writing to `var` from `task2`. Therefore the value of `var` can be unpredictable.

Though `task3` calls `increment` inside a critical section, other tasks do not use the same critical section. The operations in the critical section of `task3` are not mutually exclusive with operations in other tasks.

Therefore, the three tasks are operating on a shared variable without common protection. In your result details, you see each pair of conflicting function calls.

	Access	Access Protections	Task	File
	Read	No protection	task1()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	No protection	task2()	data_race .c
	Read	No protection	task1()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	**Critical section begin_critical_section...end_critical_section**	task3()	data_race .c
	Read	No protection	task2()	data_race .c
	Write (Non atomic) Operation might involve multiple machine instructions	**Critical section begin_critical_section...end_critical_section**	task3()	data_race .c

If you click the  icon, you see the function call sequence starting from the entry point to the read or write operation. You also see that the operation starting from `task3` is in a critical section. The **Access Protections** entry shows the lock and unlock function that begin and end the critical section. In this example, you see the functions `begin_critical_section` and `end_critical_section`.



Correction — Place Operation in Critical Section

One possible correction is to place the operation in critical section. You can implement the critical section in multiple ways. For instance:

- You can place `var++` in a critical section. When `task1` enters its critical section, the other tasks cannot enter their critical sections until `task1` leaves its critical section. The operation `var++` from the three tasks cannot interfere with each other.

  To implement the critical section, in the function `increment`, place the operation `var ++` between calls to `begin_critical_section` and `end_critical_section`.

```
int var;

void begin_critical_section(void);
void end_critical_section(void);

void increment(void) {
      begin_critical_section();
      var++;
      end_critical_section();
}

void task1(void)  {
      increment();
}

void task2(void)  {
      increment();
}

void task3(void)  {
      increment();
}
```

- You can place the call to `increment` in the same critical section in the three tasks. When `task1` enters its critical section, the other tasks cannot enter their critical sections until `task1` leaves its critical section. The calls to `increment` from the three tasks cannot interfere with each other.

  To implement the critical section, in each of the three tasks, call `increment` between calls to `begin_critical_section` and `end_critical_section`.

```
int var;

void begin_critical_section(void);
void end_critical_section(void);

void increment(void) {
      var++;
}

void task1(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}

void task2(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}

void task3(void)  {
     begin_critical_section();
     increment();
     end_critical_section();
}
```

Correction — Make Tasks Temporally Exclusive

Another possible correction is to make the tasks, `task1`, `task2` and `task3`, temporally exclusive. Temporally exclusive tasks cannot execute concurrently.

On the **Configuration** pane, specify the following additional options:

Option	Value
`Temporally exclusive tasks (-temporal-exclusions-file)`	`task1 task2 task3`

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

On the command-line, you can use the following:

```
 polyspace-bug-finder
     -temporal-exclusions-file "C:\exclusions_file.txt"
```

where the file `C:\exclusions_file.txt` has the following line:

```
task1 task2 task3
```

Example - Unprotected Operation in Threads Created with `pthread_create`

```
#include <pthread.h>

pthread_mutex_t count_mutex;
long long count;


void* increment_count(void* args)
{
    count = count + 1;
    return NULL;
}

void* set_count(void *args)
{
    long long c;
    c = count;
    return NULL;
}

int main(void)
{
    pthread_t thread_increment;
    pthread_t thread_get;

    pthread_create(&thread_increment, NULL, increment_count, NULL);
    pthread_create(&thread_get, NULL, set_count, NULL);

    pthread_join(thread_get, NULL);
    pthread_join(thread_increment, NULL);

    return 1;
}
```

In this example, Bug Finder detects the creation of separate threads with `pthread_create`. The **Data race** defect is raised because the operation `count = count + 1` in the thread with id `thread_increment` conflicts with the operation `c = count` in the thread with id `thread_get`. The variable `count` is accessed in multiple threads without a common protection.

The two conflicting operations are nonatomic. The operation `c = count` is nonatomic on 32-bit targets. See the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server..

Correction — Protect Operations with `pthread_mutex_lock` and `pthread_mutex_unlock` Pair

To prevent concurrent access on the variable `count`, protect operations on `count` with a critical section. Use the functions `pthread_mutex_lock` and `pthread_mutex_unlock` to implement the critical section.

```
#include <pthread.h>

pthread_mutex_t count_mutex;
long long count;


void* increment_count(void* args)
{
    pthread_mutex_lock(&count_mutex);
    count = count + 1;
    pthread_mutex_unlock(&count_mutex);
    return NULL;
}

void* set_count(void *args)
{
    long long c;
    pthread_mutex_lock(&count_mutex);
    c = count;
    pthread_mutex_unlock(&count_mutex);
    return NULL;
}

int main(void)
{
    pthread_t thread_increment;
    pthread_t thread_get;
```

```
    pthread_create(&thread_increment, NULL, increment_count, NULL);
    pthread_create(&thread_get, NULL, set_count, NULL);

    pthread_join(thread_get, NULL);
    pthread_join(thread_increment, NULL);

    return 1;
}
```

Check Information

Group: 10. Concurrency (CON)

See Also

External Websites

CON52-CPP

Introduced in R2019a

CERT C++: CON53-CPP

Avoid deadlock by locking in a predefined order

Description

Rule Definition

Avoid deadlock by locking in a predefined order.

Examples

Deadlock

Description

Deadlock occurs when multiple tasks are stuck in their critical sections (CS) because:

- Each CS waits for another CS to end.
- The critical sections (CS) form a closed cycle. For example:
  - CS #1 waits for CS #2 to end, and CS #2 waits for CS #1 to end.
  - CS #1 waits for CS #2 to end, CS #2 waits for CS #3 to end and CS #3 waits for CS #1 to end.

Polyspace expects critical sections of code to follow a specific format. A critical section lies between a call to a lock function and a call to an unlock function. When a task `my_task` calls a lock function `my_lock`, other tasks calling `my_lock` must wait until `my_task` calls the corresponding unlock function. Both lock and unlock functions must have the form `void func(void)`.

To find this defect, you must specify the multitasking options before analysis. To specify these options, on the **Configuration** pane, select **Multitasking**.

Risk

Each task waits for a critical section in another task to end and is unable to proceed. The program can freeze indefinitely.

Fix

The fix depends on the root cause of the defect. You can try to break the cyclic order between the tasks in one of these ways:

- Write down all critical sections involved in the deadlock in a certain sequence. Whenever you call the lock functions of the critical sections within a task, respect the order in that sequence. See an example below.
- If one of the critical sections involved in a deadlock occurs in an interrupt, try to disable all interrupts during critical sections in all tasks. See `Disabling all interrupts (-routine-disable-interrupts -routine-enable-interrupts)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Reviewing this defect is an opportunity to check if all operations in your critical section are really meant to be executed as an atomic block. It is a good practice to keep critical sections at a bare minimum.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Deadlock with Two Tasks

```
void task1(void);
void task2(void);

int var;
void perform_task_cycle(void) {
 var++;
}

void begin_critical_section_1(void);
void end_critical_section_1(void);

void begin_critical_section_2(void);
```

```
void end_critical_section_2(void);

void task1() {
 while(1) {
    begin_critical_section_1();
    begin_critical_section_2();
    perform_task_cycle();
    end_critical_section_2();
    end_critical_section_1();
 }
}

void task2() {
 while(1) {
    begin_critical_section_2();
    begin_critical_section_1();
    perform_task_cycle();
    end_critical_section_1();
    end_critical_section_2();
 }
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	**Specification**	
Configure multitasking manually	☑	

Entry points	`task1`
	
	`task2`	

Critical section details	**Starting routine**	**Ending routine**
	`begin_critical_section_1`	`end_critical_section_1`
	`begin_critical_section_2`	`end_critical_section_2`

A **Deadlock** occurs because the instructions can execute in the following sequence:

1. `task1` calls `begin_critical_section_1`.
2. `task2` calls `begin_critical_section_2`.

3. `task1` reaches the instruction `begin_critical_section_2();`. Since `task2` has already called `begin_critical_section_2`, `task1` waits for `task2` to call `end_critical_section_2`.
4. `task2` reaches the instruction `begin_critical_section_1();`. Since `task1` has already called `begin_critical_section_1`, `task2` waits for `task1` to call `end_critical_section_1`.

Correction-Follow Same Locking Sequence in Both Tasks

One possible correction is to follow the same sequence of calls to lock and unlock functions in both `task1` and `task2`.

```
void task1(void);
void task2(void);
void perform_task_cycle(void);

void begin_critical_section_1(void);
void end_critical_section_1(void);

void begin_critical_section_2(void);
void end_critical_section_2(void);

void task1() {
 while(1) {
    begin_critical_section_1();
    begin_critical_section_2();
    perform_task_cycle();
    end_critical_section_2();
    end_critical_section_1();
 }
}

void task2() {
 while(1) {
    begin_critical_section_1();
    begin_critical_section_2();
    perform_task_cycle();
    end_critical_section_2();
    end_critical_section_1();
 }
}
```

Example - Deadlock with More Than Two Tasks

```
int var;
void performTaskCycle() {
 var++;
}

void lock1(void);
void lock2(void);
void lock3(void);


void unlock1(void);
void unlock2(void);
void unlock3(void);

void task1() {
 while(1) {
    lock1();
    lock2();
    performTaskCycle();
    unlock2();
    unlock1();
 }
}

void task2() {
 while(1) {
    lock2();
    lock3();
    performTaskCycle();
    unlock3();
    unlock2();
 }
}

void task3() {
 while(1) {
    lock3();
    lock1();
    performTaskCycle();
```

```
    unlock1();
    unlock3();
 }
}
```

In this example, to emulate multitasking behavior, you must specify the following options:

Option	Specification	
Configure multitasking manually	☑	

Entry points	`task1`
	`task2`
	`task3`	

Critical section details	**Starting routine**	**Ending routine**
	`lock1`	`unlock1`
	`lock2`	`unlock2`
	`lock3`	`unlock3`

A **Deadlock** occurs because the instructions can execute in the following sequence:

1. `task1` calls `lock1`.
2. `task2` calls `lock2`.
3. `task3` calls `lock3`.
4. `task1` reaches the instruction `lock2();`. Since `task2` has already called `lock2`, `task1` waits for call to `unlock2`.
5. `task2` reaches the instruction `lock3();`. Since `task3` has already called `lock3`, `task2` waits for call to `unlock3`.
6. `task3` reaches the instruction `lock1();`. Since `task1` has already called `lock1`, `task3` waits for call to `unlock1`.

Correction — Break Cyclic Order

To break the cyclic order between critical sections, note every lock function in your code in a certain sequence, for example:

1. `lock1`

2. `lock2`
3. `lock3`

If you use more than one lock function in a task, use them in the order in which they appear in the sequence. For example, you can use `lock1` followed by `lock2` but not `lock2` followed by `lock1`.

```
int var;
void performTaskCycle() {
 var++;
}

void lock1(void);
void lock2(void);
void lock3(void);

void unlock1(void);
void unlock2(void);
void unlock3(void);

void task1() {
 while(1) {
    lock1();
    lock2();
    performTaskCycle();
    unlock2();
    unlock1();
 }
}

void task2() {
 while(1) {
    lock2();
    lock3();
    performTaskCycle();
    unlock3();
    unlock2();
 }
}

void task3() {
```

```
 while(1) {
    lock1();
    lock3();
    performTaskCycle();
    unlock3();
    unlock1();
 }
}
```

Check Information

Group: 10. Concurrency (CON)

See Also

External Websites

CON53-CPP

Introduced in R2019a

CERT C++: CON54-CPP

Wrap functions that can spuriously wake up in a loop

Description

Rule Definition

Wrap functions that can spuriously wake up in a loop.

Examples

Function that can spuriously wake up not wrapped in loop

Description

Function that can spuriously wake up not wrapped in loop occurs when the following wait-on-condition functions are called from outside a loop:

- C functions:
  - `cnd_wait()`
  - `cnd_timedwait()`
- POSIX functions:
  - `pthread_cond_wait()`
  - `pthread_cond_timedwait()`
- C++ `std::condition_variable` and `std::condition_variable_any` class member functions:
  - `wait()`
  - `wait_until()`
  - `wait_for()`

Wait-on-condition functions pause the execution of the calling thread when a specified condition is met. The thread wakes up and resumes once another thread notifies it with `cnd_broadcast()` or an equivalent function. The wake-up notification can be spurious or malicious.

Risk

If a thread receives a spurious wake-up notification and the condition of the wait-on-condition function is not checked, the thread can wake up prematurely. The wake-up can cause unexpected control flow, indefinite blocking of other threads, or denial of service.

Fix

Wrap wait-on-condition functions that can wake up spuriously in a loop. The loop checks the wake-up condition after a possible spurious wake-up notification.

Example - `cnd_wait()` Not Wrapped in Loop

```
#include <stdio.h>
#include <stddef.h>
#include <threads.h>

#define THRESHOLD 100

static mtx_t lock;
static cnd_t cond;

void func(int input)
{
    if (thrd_success != mtx_lock(&lock)) {
        /* Handle error */
    }
    /* test condition to pause thread */
    if (input > THRESHOLD) {
        if (thrd_success != cnd_wait(&cond, &lock)) {
            /* Handle error */
        }
    }
    /* Proceed if condition to pause does not hold */


    if (thrd_success != mtx_unlock(&lock)) {
        /* Handle error */
    }
```

```
}
```

In this example, the thread uses `cnd_wait()` to pause execution when `input` is greater than `THRESHOLD`. The paused thread can resume if another thread uses `cnd_broadcast()`, which notifies all the threads. This notification causes the thread to wake up even if the pause condition is still true.

Correction — Wrap `cnd_wait()` in a `while` Loop

One possible correction is to wrap `cnd_wait()` in a `while` loop. The loop checks the pause condition after the thread receives a possible spurious wake-up notification.

```
#include <stdio.h>
#include <stddef.h>
#include <threads.h>

#define THRESHOLD 100

static mtx_t lock;
static cnd_t cond;

void func(int input)
{
    if (thrd_success != mtx_lock(&lock)) {
        /* Handle error */
    }
    /* test condition to pause thread */
    while (input > THRESHOLD) {
        if (thrd_success != cnd_wait(&cond, &lock)) {
            /* Handle error */
        }
    }
    /* Proceed if condition to pause does not hold */


    if (thrd_success != mtx_unlock(&lock)) {
        /* Handle error */
    }
}
```

Check Information

Group: 10. Concurrency (CON)

See Also

External Websites

CON54-CPP

Introduced in R2019a

49. Miscellaneous (MSC)

CERT C++: ENV30-C

Do not modify the object referenced by the return value of certain functions

Description

Rule Definition

Do not modify the object referenced by the return value of certain functions.

Examples

Modification of internal buffer returned from nonreentrant standard function

Description

Modification of internal buffer returned from nonreentrant standard function occurs when the following happens:

- A nonreentrant standard function returns a pointer.
- You attempt to write to the memory location that the pointer points to.

Nonreentrant standard functions that return a non `const`-qualified pointer to an internal buffer include `getenv`, `getlogin`, `crypt`, `setlocale`, `localeconv`, `strerror` and others.

Risk

Modifying the internal buffer that a nonreentrant standard function returns can cause the following issues:

- It is possible that the modification does not succeed or alters other internal data.

  For instance, `getenv` returns a pointer to an environment variable value. If you modify this value, you alter the environment of the process and corrupt other internal data.

- Even if the modification succeeds, it is possible that a subsequent call to the same standard function does not return your modified value.

  For instance, you modify the environment variable value that `getenv` returns. If another process, thread, or signal handler calls `setenv`, the modified value is overwritten. Therefore, a subsequent call to `getenv` does not return your modified value.

Fix

Avoid modifying the internal buffer using the pointer returned from the function.

Example - Modification of `getenv` Return Value

```
#include <stdlib.h>
#include <string.h>

void printstr(const char*);

void func() {
    char* env = getenv("LANGUAGE");
    if (env != NULL) {
        strncpy(env, "C", 1);
        printstr(env);
    }
}
```

In this example, the first argument of `strncpy` is the return value from a nonreentrant standard function `getenv`. The behavior can be undefined because `strncpy` modifies this argument.

Correction - Copy Return Value of `getenv` and Modify Copy

One possible solution is to copy the return value of `getenv` and pass the copy to the `strncpy` function.

```
#include <stdlib.h>
#include <string.h>
enum {
    SIZE20 = 20
};

void printstr(const char*);
```

```
void func() {
    char* env = getenv("LANGUAGE");
    if (env != NULL) {
        char env_cp[SIZE20];
        strncpy(env_cp, env, SIZE20);
        strncpy(env_cp, "C", 1);
        printstr(env_cp);
    }
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

ENV30-C

Introduced in R2019a

CERT C++: ENV31-C

Do not rely on an environment pointer following an operation that may invalidate it

Description

Rule Definition

Do not rely on an environment pointer following an operation that may invalidate it.

Examples

Environment pointer invalidated by previous operation

Description

Environment pointer invalidated by previous operation occurs when you use the third argument of *main()* in a hosted environment to access the environment after an operation modifies the environment. In a hosted environment, many C implementations support the nonstandard syntax:

```
main (int argc, char *argv[], char *envp[])
```

A call to a `setenv` or `putenv` family function modifies the environment pointed to by `*envp`.

Risk

When you modify the environment through a call to a `setenv` or `putenv` family function, the environment memory can potentially be reallocated. The hosted environment pointer is not updated and might point to an incorrect location. A call to this pointer can return unexpected results or cause an abnormal program termination.

Fix

Do not use the hosted environment pointer. Instead, use global external variable `environ` in Linux, `_environ` or `_wenviron` in Windows, or their equivalent. When you modify the environment, these variables are updated.

Example - Access Environment Through Pointer envp

```
#include <stdio.h>
#include <stdlib.h>

extern int check_arguments(int argc, char **argv, char **envp);
extern void use_envp(char **envp);

/* envp is from main function */
int func(char **envp)
{
    /* Call to setenv may cause environment
     *memory to be reallocated
     */
    if (setenv(("MY_NEW_VAR"),("new_value"),1) != 0)
    {
        /* Handle error */
        return -1;
    }
    /* envp not updated after call to setenv, and may
     *point to incorrect location.
     **/
    if (envp != ((void *)0)) {
        use_envp(envp);
/* No defect on second access to
*envp because defect already raised */
    }
    return 0;
}

void  main(int argc, char **argv, char **envp)
{
    if (check_arguments(argc, argv, envp))
    {
        (void)func(envp);
    }
}
```

In this example, `envp` is accessed inside `func()` after a call to `setenv` that can reallocate the environment memory. `envp` can point to an incorrect location because it is not updated after `setenv` modifies the environment. No defect is raised when `use_envp()` is called because the defect is already raised on the previous line of code.

Correction — Use Global External Variable `environ`

One possible correction is to access the environment by using a variable that is always updated after a call to `setenv`. For instance, in the following code, the pointer `envp` is still available from `main()`, but the environment is accessed in `func()` through the global external variable `environ`.

```
#include <stdio.h>
#include <stdlib.h>
extern char **environ;

extern int check_arguments(int argc, char **argv, char **envp);
extern void use_envp(char **envp);

int func(void)
{
    if (setenv(("MY_NEW_VAR"), ("new_value"),1) != 0) {
        /* Handle error */
        return -1;
    }
  /* Use global external variable environ
   *which is always updated after a call to setenv */

    if (environ != NULL) {
        use_envp(environ);
    }
    return 0;
}

void  main(int argc, char **argv, char **envp)
{
    if (check_arguments(argc, argv, envp))
    {
        (void)func();
    }
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

ENV31-C

Introduced in R2019a

CERT C++: ENV32-C

All exit handlers must return normally

Description

Rule Definition

All exit handlers must return normally.

Examples

Abnormal termination of exit handler

Description

Abnormal termination of exit handler looks for registered exit handlers. Exit handlers are registered with specific functions such as `atexit`, (WinAPI) `_onexit`, or `at_quick_exit()`. If the exit handler calls a function that interrupts the program's expected termination sequence, Polyspace raises a defect. Some functions that can cause abnormal exits are `exit`, `abort`, `longjmp`, or (WinAPI) `_onexit`.

Risk

If your exit handler terminates your program, you can have undefined behavior. Abnormal program termination means other exit handlers are not invoked. These additional exit handlers may do additional clean up or other required termination steps.

Fix

In inside exit handlers, remove calls to functions that prevent the exit handler from terminating normally.

Example - Exit Handler With Call to `exit`

```
#include <stdlib.h>
```

```
volatile int some_condition = 1;
void demo_exit1(void)
{
    /* ... Cleanup code ... */
    return;
}
void exitabnormalhandler(void)
{
    if (some_condition)
    {
        /* Clean up */
        exit(0);
    }
    return;
}

int demo_install_exitabnormalhandler(void)
{

    if (atexit(demo_exit1) != 0) /* demo_exit1() performs additional cleanup */
    {
        /* Handle error */
    }
    if (atexit(exitabnormalhandler) != 0)
    {
        /* Handle error */
    }
    /* ... Program code ... */
    return 0;
}
```

In this example, `demo_install_exitabnormalhandler` registers two exit handlers, `demo_exit1` and `exitabnormalhandler`. Exit handlers are invoked in the reverse order of which they are registered. When the program ends, `exitabnormalhandler` runs, then `demo_exit1`. However, `exitabnormalhandler` calls `exit` interrupting the program exit process. Having this `exit` inside an exit handler causes undefined behavior because the program is not finished cleaning up safely.

Correction — Remove `exit` from Exit Handler

One possible correction is to let your exit handlers terminate normally. For this example, `exit` is removed from `exitabnormalhandler`, allowing the exit termination process to complete as expected.

```
#include <stdlib.h>

volatile int some_condition = 1;
void demo_exit1(void)
{
    /* ... Cleanup code ... */
    return;
}
void exitabnormalhandler(void)
{
    if (some_condition)
    {
        /* Clean up */
        /* Return normally */
    }
    return;
}

int demo_install_exitabnormalhandler(void)
{

    if (atexit(demo_exit1) != 0) /* demo_exit1() continues clean up */
    {
        /* Handle error */
    }
    if (atexit(exitabnormalhandler) != 0)
    {
        /* Handle error */
    }
    /* ... Program code ... */
    return 0;
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

ENV32-C

Introduced in R2019a

CERT C++: ENV33-C

Do not call system()

Description

Rule Definition

Do not call system().

Examples

Unsafe call to a system function

Description

Unsafe call to a system function occurs when you use a function that invokes an implementation-defined command processor. These functions include:

- The C standard `system()` function.
- The POSIX `popen()` function.
- The Windows `_popen()` and `_wpopen()` functions.

Risk

If the argument of a function that invokes a command processor is not sanitized, it can cause exploitable vulnerabilities. An attacker can execute arbitrary commands or read and modify data anywhere on the system.

Fix

Do not use a `system`-family function to invoke a command processor. Instead, use safer functions such as POSIX `execve()` and WinAPI `CreateProcess()`.

Example - `system()` Called

```
# include <string.h>
# include <stdlib.h>
# include <stdio.h>
# include <unistd.h>

enum {
SIZE512=512,
SIZE3=3};

void func(char *arg)
{
    char buf[SIZE512];
    int retval=sprintf(buf, "/usr/bin/any_cmd %s", arg);

    if (retval<=0 || retval>SIZE512){
        /* Handle error */
        abort();
    }
    /* Use of system() to pass any_cmd with
    unsanitized argument to command processor */

    if (system(buf) == -1) {
    /* Handle error */
  }
}
```

In this example, `system()` passes its argument to the host environment for the command processor to execute. This code is vulnerable to an attack by command-injection.

Correction — Sanitize Argument and Use `execve()`

In the following code, the argument of `any_cmd` is sanitized, and then passed to `execve()` for execution. `exec`-family functions are not vulnerable to command-injection attacks.

```
# include <string.h>
# include <stdlib.h>
# include <stdio.h>
# include <unistd.h>

enum {
SIZE512=512,
```

```
SIZE3=3};


void func(char *arg)
{
  char *const args[SIZE3] = {"any_cmd", arg, NULL};
  char  *const env[] = {NULL};

  /* Sanitize argument */

  /* Use execve() to execute any_cmd. */

  if (execve("/usr/bin/time", args, env) == -1) {
    /* Handle error */
  }
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

ENV33-C

Introduced in R2019a

CERT C++: ENV34-C

Do not store pointers returned by certain functions

Description

Rule Definition

Do not store pointers returned by certain functions.

Examples

Misuse of return value from nonreentrant standard function

Description

Misuse of return value from nonreentrant standard function occurs when these events happen in this sequence:

1. You point to the buffer returned from a nonreentrant standard function such as `getenv` or `setlocale`.

   ```
   user = getenv("USER");
   ```

2. You call that nonreentrant standard function again.

   ```
   user2 = getenv("USER2");
   ```

3. You use or dereference the pointer from the first step expecting the buffer to remain unmodified since that step. In the meantime, the call in the second step has modified the buffer.

   For instance:

   ```
   var=*user;
   ```

In some cases, the defect might appear even if you do not call the `getenv` function a second time but simply return the pointer. For instance:

```
char* func() {
     user=getenv("USER");
     .
     .
     return user;
}
```

For information on which functions are covered by this defect, see documentation on nonreentrant standard functions.

Risk

The C Standard allows nonreentrant functions such as `getenv` to return a pointer to a *static* buffer. Because the buffer is static, a second call to `getenv` modifies the buffer. If you continue to use the pointer returned from the first call past the second call, you can see unexpected results. The buffer that it points to no longer has values from the first call.

The defect appears even if you do not call `getenv` a second time but simply return the pointer. The reason is that someone calling your function might use the returned pointer *after* a second call to `getenv`. By returning the pointer from your call to `getenv`, you make your function unsafe to use.

The same rationale is true for other nonreentrant functions covered by this defect.

Fix

After the first call to `getenv`, make a copy of the buffer that the returned pointer points to. After the second call to `getenv`, use this copy. Even if the second call modifies the buffer, your copy is untouched.

Example - Return from `getenv` Used After Second Call to `getenv`

```
#include <stdlib.h>
#include <string.h>

int func()
{
    int result = 0;

    char *home = getenv("HOME");   /* First call */
    if (home != NULL) {
        char *user = NULL;
        char *user_name_from_home = strrchr(home, '/');
```

```
        if (user_name_from_home != NULL) {
            user = getenv("USER");   /* Second call */
            if ((user != NULL) &&
                (strcmp(user, user_name_from_home) == 0))
            {
                result = 1;
            }
        }
    }
    return result;
}
```

In this example, the pointer `user_name_from_home` is derived from the pointer `home`. `home` points to the buffer returned from the first call to `getenv`. Therefore, `user_name_from_home` points to a location in the same buffer.

After the second call to `getenv`, the buffer is modified. If you continue to use `user_name_from_home`, you can get unexpected results.

Correction — Make Copy of Buffer Before Second Call

If you want to access the buffer from the first call to `getenv` past the second call, make a copy of the buffer after the first call. One possible correction is to use the `strdup` function to make the copy.

```
#include <stdlib.h>
#include <string.h>

int func()
{
    int result = 0;

    char *home = getenv("HOME");
    if (home != NULL) {
        char *user = NULL;
        char *user_name_from_home = strrchr(home, '/');
        if (user_name_from_home != NULL) {
            /* Make copy before second call */
            char *saved_user_name_from_home = strdup(user_name_from_home);
            if (saved_user_name_from_home != NULL) {
                user = getenv("USER");
                if ((user != NULL) &&
                    (strcmp(user, saved_user_name_from_home) == 0))
                {
```

```
                    result = 1;
                }
                free(saved_user_name_from_home);
            }
        }
    }
    return result;
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

ENV34-C

Introduced in R2019a

CERT C++: FLP30-C

Do not use floating-point variables as loop counters

Description

Rule Definition

Do not use floating-point variables as loop counters.

Examples

Floating type or multiple for loop counters

Description

The checker flags these situations:

- The `for` loop index has a floating point type.
- More than one loop counter is incremented in the `for` loop increment statement.

  For instance:

  ```
  for(i=0, j=0; i<10 && j < 10;i++, j++) {}
  ```
- A loop counter is not incremented in the `for` loop increment statement.

  For instance:

  ```
  for(i=0; i<10;) {}
  ```

  Even if you increment the loop counter in the loop body, the checker still raises a violation.

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

FLP30-C

Introduced in R2019a

CERT C++: FLP32-C

Prevent or detect domain and range errors in math functions

Description

Rule Definition

Prevent or detect domain and range errors in math functions.

Examples

Invalid use of standard library floating point routine

Description

Invalid use of standard library floating point routine occurs when you use invalid arguments with a floating point function from the standard library. This defect picks up:

- Rounding and absolute value routines

  ```
  ceil, fabs, floor, fmod
  ```

- Fractions and division routines

  ```
  fmod, modf
  ```

- Exponents and log routines

  ```
  frexp, ldexp, sqrt, pow, exp, log, log10
  ```

- Trigonometry function routines

  ```
  cos, sin, tan, acos, asin, atan, atan2, cosh, sinh, tanh, acosh,
  asinh, atanh
  ```

Risk

Domain errors on standard library floating point functions result in implementation-defined values. If you use the function return value in subsequent computations, you can see unexpected results.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the function argument acquires invalid values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

It is a good practice to handle for domain errors before using a standard library floating point function. For instance, before calling the `acos` function, check if the argument is in [-1.0, 1.0] and handle the error.

See examples of fixes below.

If you do not want to fix the issue, for instance, when you handle infinities in your code, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Arc Cosine Operation

```
#include <math.h>

double arccosine(void) {
    double degree = 5.0;
    return acos(degree);
}
```

The input value to `acos` must be in the interval `[-1,1]`. This input argument, `degree`, is outside this range.

Correction — Change Input Argument

One possible correction is to change the input value to fit the specified range. In this example, change the input value from degrees to radians to fix this defect.

```
#include <math.h>
```

```
double arccosine(void) {
    double degree = 5.0;
    double radian = degree * 3.14159 / 180.;
    return acos(radian);
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

FLP32-C

Introduced in R2019a

CERT C++: FLP34-C

Ensure that floating-point conversions are within range of the new type

Description

Rule Definition

Ensure that floating-point conversions are within range of the new type.

Examples

Float conversion overflow

Description

Float conversion overflow occurs when converting a floating point number to a smaller floating point data type. If the variable does not have enough memory to represent the original number, the conversion overflows.

The exact storage allocation for different floating point types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Overflows can result in unpredictable values from computations. The result can be infinity or the maximum finite value depending on the rounding mode used in the implementation. If you use the result of an overflowing conversion in subsequent computations and do not account for the overflow, you can see unexpected results.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variable being converted acquires its current value You can implement the fix on any event in the

sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

You can fix the defect by:

- Using a bigger data type for the result of the conversion so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

In general, avoid conversions to smaller floating point types.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Converting from `double` to `float`

```
float convert(void) {

    double diam = 1e100;
    return (float)diam;
}
```

In the return statement, the variable `diam` of type double (64 bits) is converted to a variable of type float (32 bits). However, the value 1^100 requires more than 32 bits to be precisely represented.

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

FLP34-C

Introduced in R2019a

CERT C++: FLP36-C

Preserve precision when converting integral values to floating-point type

Description

Rule Definition

Preserve precision when converting integral values to floating-point type.

Examples

Precision loss in integer to float conversion

Description

Precision loss from integer to float conversion occurs when you cast an integer value to a floating-point type that cannot represent the original integer value.

For instance, the `long int` value `1234567890L` is too large for a variable of type `float` .

Risk

If the floating-point type cannot represent the integer value, the behavior is undefined (see C11 standard, 6.3.1.4, paragraph 2). For instance, least significant bits of the variable value can be dropped leading to unexpected results.

Fix

Convert to a floating-point type that can represent the integer value.

For instance, if the `float` data type cannot represent the integer value, use the `double` data type instead.

When writing a function that converts an integer to floating point type, before the conversion, check if the integer value can be represented in the floating-point type. For

instance, `DBL_MANT_DIG * log2(FLT_RADIX)` represents the number of base-2 digits in the type `double`. Before conversion to the type `double`, check if this number is greater than or equal to the precision of the integer that you are converting. To determine the precision of an integer `num`, use this code:

```
size_t precision = 0;
while (num != 0) {
   if (num % 2 == 1) {
     precision++;
   }
   num >>= 1;
}
```

Some implementations provide a builtin function to determine the precision of an integer. For instance, GCC provides the function `__builtin_popcount`.

Example - Conversion of Large Integer to Floating-Point Type

```
#include <stdio.h>

int main(void) {
  long int big = 1234567890L;
  float approx = big;
  printf("%ld\n", (big - (long int)approx));
  return 0;
}
```

In this example, the `long int` variable `big` is converted to `float`.

Correction — Use a Wider Floating-Point Type

One possible correction is to convert to the `double` data type instead of `float`.

```
#include <stdio.h>

int main(void) {
  long int big = 1234567890L;
  double approx = big;
  printf("%ld\n", (big - (long int)approx));
  return 0;
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

FLP36-C

Introduced in R2019a

CERT C++: FLP37-C

Do not use object representations to compare floating-point values

Description

Rule Definition

Do not use object representations to compare floating-point values.

Examples

Memory comparison of float-point values

Description

Memory comparison of float-point values occurs when you compare the object representation of floating-point values or the object representation of structures containing floating-point members. When you use the functions `memcmp`, `bcmp`, or `wmemcmp` to perform the bit pattern comparison, the defect is raised.

Risk

The object representation of floating-point values uses specific bit patterns to encode those values. Floating-point values that are equal, for instance `-0.0` and `0.0` in the IEC 60559 standard, can have different bit patterns in their object representation. Similarly, floating-point values that are not equal can have the same bit pattern in their object representation.

Fix

When you compare structures containing floating-point members, compare the structure members individually.

To compare two floating-point values, use the == or != operators. If you follow a standard that discourages the use of these operators, such as MISRA, ensure that the difference between the floating-point values is within an acceptable range.

Example - Using `memcmp` to Compare Structures with Floating-Point Members

```
#include <string.h>

typedef struct {
    int i;
    float f;
} myStruct;

extern void initialize_Struct(myStruct *);

int func_cmp(myStruct *s1, myStruct *s2) {
/* Comparison between structures containing
* floating-point members */
    return memcmp
        ((const void *)s1, (const void *)s2, sizeof(myStruct));
}

void func(void) {
    myStruct s1, s2;
    initialize_Struct(&s1);
    initialize_Struct(&s2);
    (void)func_cmp(&s1, &s2);
}
```

In this example, `func_cmp()` calls `memcmp()` to compare the object representations of structures `s1` and `s2`. The comparison might be inaccurate because the structures contain floating-point members.

Correction — Compare Structure Members Individually

One possible correction is to compare the structure members individually and to ensure that the difference between the floating-point values is within an acceptable range defined by ESP.

```
 #include <string.h>

typedef struct {
    int i;
    float f;
```

```
} myStruct;

extern void initialize_Struct(myStruct *);

#define ESP 0.00001

int func_cmp(myStruct *s1, myStruct *s2) {

/*Structure members are compared individually */
    return ((s1->i == s2->i) &&
            (fabsf(s1->f - s2->f) <= ESP));
}

void func(void) {
    myStruct s1, s2;
    initialize_Struct(&s1);
    initialize_Struct(&s2);
    (void)func_cmp(&s1, &s2);
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

FLP37-C

Introduced in R2019a

CERT C++: MSC30-C

Do not use the rand() function for generating pseudorandom numbers

Description

Rule Definition

Do not use the rand() function for generating pseudorandom numbers.

Examples

Vulnerable pseudo-random number generator

Description

The **Vulnerable pseudo-random number generator** identifies uses of cryptographically weak pseudo-random number generator (PRNG) routines.

The list of cryptographically weak routines flagged by this checker include:

- `rand`, `random`
- `drand48`, `lrand48`, `mrand48`, `erand48`, `nrand48`, `jrand48`, and their `_r` equivalents such as `drand48_r`
- `RAND_pseudo_bytes`

Risk

These cryptographically weak routines are predictable and must not be used for security purposes. When a predictable random value controls the execution flow, your program is vulnerable to malicious attacks.

Fix

Use more cryptographically sound random number generators, such as `CryptGenRandom` (Windows), `OpenSSL/RAND_bytes`(Linux/UNIX).

Example - Random Loop Numbers

```
#include <stdio.h>
#include <stdlib.h>

volatile int rd = 1;
int main(int argc, char *argv[])
{
    int j, r, nloops;
    struct random_data buf;
    int i = 0;

    nloops = rand();

    for (j = 0; j < nloops; j++) {
        if (random_r(&buf, &i))
            exit(1);
        printf("random_r: %ld\n", (long)i);
    }
    return 0;
}
```

This example uses `rand` and `random_r` to generate random numbers. If you use these functions for security purposes, these PRNGs can be the source of malicious attacks.

Correction — Use Stronger PRNG

One possible correction is to replace the vulnerable PRNG with a stronger random number generator.

```
#include <stdio.h>
#include <stdlib.h>
#include <openssl/rand.h>

volatile int rd = 1;
int main(int argc, char* argv[])
{
    int j, r, nloops;
    unsigned char buf;
    unsigned int seed;
    int i = 0;

    if (argc != 3)
```

```
    {
        fprintf(stderr, "Usage: %s <seed> <nloops>\n", argv[0]);
        exit(EXIT_FAILURE);
    }

    seed = atoi(argv[1]);
    nloops = atoi(argv[2]);

    for (j = 0; j < nloops; j++) {
        if (RAND_bytes(&buf, i) != 1)
            exit(1);
        printf("RAND_bytes: %u\n", (unsigned)buf);
    }
    return 0;
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

MSC30-C

Introduced in R2019a

CERT C++: MSC32-C

Properly seed pseudorandom number generators

Description

Rule Definition

Properly seed pseudorandom number generators.

Examples

Deterministic random output from constant seed

Description

Deterministic random output from constant seed detects random standard functions that when given a constant seed, have deterministic output.

Risk

When some random functions, such as `srand`, `srandom`, and `initstate`, have constant seeds, the results produce the same output every time that your program is run. A hacker can disrupt your program if they know how your program behaves.

Fix

Use a different random standard function or use a nonconstant seed.

Some standard random routines are inherently cryptographically weak on page 1-885, and should not be used for security purposes.

Example - Random Number Generator Initialization

```
#include <stdlib.h>
```

```
void random_num(void)
{
    srand(12345U);
    /* ... */
}
```

This example initializes a random number generator using `srand` with a constant seed. The random number generation is deterministic, making this function cryptographically weak.

Correction — Use Different Random Number Generator

One possible correction is to use a random number generator that does not require a seed. This example uses `rand_s`.

```
#define _CRT_RAND_S
#include <stdlib.h>
#include <stdio.h>

unsigned int random_num_time(void)
{

    unsigned int number;
    errno_t err;
    err = rand_s(&number);

    if(err != 0)
    {
        return number;
    }
    else
    {
        return err;
    }
}
```

Predictable random output from predictable seed

Description

Predictable random output from predictable seed looks for random standard functions that use a nonconstant but predictable seed. Examples of predictable seed generators are `time`, `gettimeofday`, and `getpid`.

Risk

When you use predictable seed values for random number generation, your random numbers are also predictable. A hacker can disrupt your program if they know how your program behaves.

Fix

You can use a different function to generate less predictable seeds.

You can also use a different random number generator that does not require a seed. For example, the Windows API function `rand_s` seeds itself by default. It uses information from the entire system, for example, system time, thread ids, system counter, and memory clusters. This information is more random and a user cannot access this information.

Some standard random routines are inherently cryptographically weak on page 1-885, and should not be used for security purposes.

Example - Seed as an Argument

```
#include <stdlib.h>
#include <time.h>

void seed_rng(int seed)
{
    srand(seed);
}

int generate_num(void)
{
    seed_rng(time(NULL) + 3);
    /* ... */
}
```

This example uses `srand` to start the random number generator with `seed` as the seed. However, `seed` is predictable because the function `time` generates it. So, an attacker can predict the random numbers generated by `srand`.

Correction — Use Different Random Number Generator

One possible correction is to use a random number generator that does not require a seed. This example uses `rand_s`.

```
#define _CRT_RAND_S

#include <stdlib.h>
#include <stdio.h>
#include <errno.h>

int generate_num(void)
{
    unsigned int number;
    errno_t err;
    err = rand_s(&number);

    if(err != 0)
    {
        return number;
    }
    else
    {
        return err;
    }
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

MSC32-C

Introduced in R2019a

CERT C++: MSC33-C

Do not pass invalid data to the asctime() function

Description

Rule Definition

Do not pass invalid data to the asctime() function.

Examples

Use of obsolete standard function

Description

Use of obsolete standard function detects calls to standard function routines that are considered legacy, removed, deprecated, or obsolete by C/C++ coding standards.

Obsolete Function	Standards	Risk	Replacement Function
`asctime`	Deprecated in POSIX.1-2008	Not thread-safe.	`strftime` or `asctime_s`
`asctime_r`	Deprecated in POSIX.1-2008	Implementation based on unsafe function `sprintf`.	`strftime` or `asctime_s`
`bcmp`	Deprecated in 4.3BSD Marked as legacy in POSIX.1-2001.	Returns from function after finding the first differing byte, making it vulnerable to timing attacks.	`memcmp`

Obsolete Function	Standards	Risk	Replacement Function
`bcopy`	Deprecated in 4.3BSD Marked as legacy in POSIX.1-2001.	Returns from function after finding the first differing byte, making it vulnerable to timing attacks.	`memcpy` or `memmove`
`brk` and `sbrk`	Marked as legacy in SUSv2 and POSIX.1-2001.		`malloc`
`bsd_signal`	Removed in POSIX.1-2008		`sigaction`
`bzero`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`memset`
`ctime`	Deprecated in POSIX.1-2008	Not thread-safe.	`strftime` or `asctime_s`
`ctime_r`	Deprecated in POSIX.1-2008	Implementation based on unsafe function `sprintf`.	`strftime` or `asctime_s`
`cuserid`	Removed in POSIX.1-2001.	Not reentrant. Precise functionality not standardized causing portability issues.	`getpwuid`
`ecvt` and `fcvt`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008	Not reentrant	`snprintf`
`ecvt_r` and `fcvt_r`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008		`snprintf`
`ftime`	Removed in POSIX.1-2008		`time`, `gettimeofday`, `clock_gettime`
`gamma`, `gammaf`, `gammal`	Function not specified in any standard because of historical variations	Portability issues.	`tgamma`, `lgamma`

Obsolete Function	Standards	Risk	Replacement Function
`gcvt`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`snprintf`
`getcontext`	Removed in POSIX.1-2008.	Portability issues.	Use POSIX thread instead.
`getdtablesize`	BSD API function not included in POSIX.1-2001	Portability issues.	`sysconf( _SC_OPEN_MAX )`
`gethostbyaddr`	Removed in POSIX.1-2008	Not reentrant	`getaddrinfo`
`gethostbyname`	Removed in POSIX.1-2008	Not reentrant	`getnameinfo`
`getpagesize`	BSD API function not included in POSIX.1-2001	Portability issues.	`sysconf( _SC_PAGESIZE )`
`getpass`	Removed in POSIX.1-2001.	Not reentrant.	`getpwuid`
`getw`	Not present in POSIX.1-2001.		`fread`
`getwd`	Marked legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`getcwd`
`index`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`strchr`
`makecontext`	Removed in POSIX.1-2008.	Portability issues.	Use POSIX thread instead.
`memalign`	Appears in SunOS 4.1.3. Not in 4.4 BSD or POSIX.1-2001		`posix_memalign`
`mktemp`	Removed in POSIX.1-2008.	Generated names are predictable and can cause a race condition.	`mkstemp` removes race risk
`pthread_attr_getstackaddr` and `pthread_attr_setstackaddr`		Ambiguities in the specification of the `stackaddr` attribute cause portability issues	`pthread_attr_getstack` and `pthread_attr_setstack`
`putw`	Not present in POSIX.1-2001.	Portability issues.	`fwrite`

Obsolete Function	Standards	Risk	Replacement Function
`qecvt` and `qfcvt`	Marked as legacy in POSIX.1-2001, removed in POSIX.1-2008		`snprintf`
`qecvt_r` and `qfcvt_r`	Marked as legacy in POSIX.1-2001, removed in POSIX.1-2008		`snprintf`
`rand_r`	Marked as obsolete in POSIX.1-2008		
`re_comp`	BSD API function	Portability issues	`regcomp`
`re_exes`	BSD API function	Portability issues	`regexec`
`rindex`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.		`strrchr`
`scalb`	Removed in POSIX.1-2008		`scalbln`, `scalblnf`, or `scalblnl`
`sigblock`	4.3BSD signal API whose origin is unclear		`sigprocmask`
`sigmask`	4.3BSD signal API whose origin is unclear		`sigprocmask`
`sigsetmask`	4.3BSD signal API whose origin is unclear		`sigprocmask`
`sigstack`	Interface is obsolete and not implemented on most platforms.	Portability issues.	`sigaltstack`
`sigvec`	4.3BSD signal API whose origin is unclear		`sigaction`
`swapcontext`	Removed in POSIX.1-2008	Portability issues.	Use POSIX threads.

Obsolete Function	Standards	Risk	Replacement Function
`tmpnam` and `tmpnam_r`	Marked as obsolete in POSIX.1-2008.	This function generates a different string each time it is called, up to TMP_MAX times. If it is called more than TMP_MAX times, the behavior is implementation-defined.	`mkstemp`, `tmpfile`
`ttyslot`	Removed in POSIX.1-2001.		
`ualarm`	Marked as legacy in POSIX.1-2001. Removed in POSIX.1-2008.	Errors are under-specified	`setitimer` or POSIX `timer_create`
`usleep`	Removed in POSIX.1-2008.		`nanosleep`
`utime`	SVr4, POSIX.1-2001. POSIX.1-2008 marks as obsolete.		
`valloc`	Marked as obsolete in 4.3BSD. Marked as legacy in SUSv2. Removed from POSIX.1-2001		`posix_memalign`
`vfork`	Removed from POSIX.1-2008	Under-specified in previous standards.	`fork`
`wcswcs`	This function was not included in the final ISO/IEC 9899:1990/ Amendment 1:1995 (E).		`wcsstr`
`WinExec`	WinAPI provides this function only for 16-bit Windows compatibility.		`CreateProcess`
`LoadModule`	WinAPI provides this function only for 16-bit Windows compatibility.		`CreateProcess`

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Printing Out Time

```
#include <stdio.h>
#include <time.h>

void timecheck_bad(int argc, char *argv[])
{
    time_t ticks;

    ticks = time(NULL);
    printf("%.24s\r\n", ctime(&ticks));
}
```

In this example, the function `ctime` formats the current time and prints it out. However, `ctime` was removed after C99 because it does not work on multithreaded programs.

Correction — Different Time Function

One possible correction is to use `strftime` instead because this function uses a set buffer size.

```
#include <stdio.h>
#include <string.h>
#include <time.h>

void timecheck_good(int argc, char *argv[])
{
    char outBuff[1025];
    time_t ticks;
    struct tm * timeinfo;

    memset(outBuff, 0, sizeof(outBuff));
```

```
    ticks = time(NULL);
    timeinfo = localtime(&ticks);
    strftime(outBuff,sizeof(outBuff),"%I:%M%p.",timeinfo);
    fprintf(stdout, outBuff);
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

MSC33-C

Introduced in R2019a

CERT C++: MSC37-C

Ensure that control never reaches the end of a non-void function

Description

Rule Definition

Ensure that control never reaches the end of a non-void function.

Examples

Missing return statement

Description

Missing return statement occurs when a function does not return a value along at least one execution path. If the return type of the function is `void`, this error does not occur.

Risk

If a function has a non-`void` return value in its signature, it is expected to return a value. The return value of this function can be used in later computations. If the execution of the function body goes through a path where a `return` statement is missing, the function return value is indeterminate. Computations with this return value can lead to unpredictable results.

Fix

In most cases, you can fix this defect by placing the `return` statement at the end of the function body.

Alternatively, you can identify which execution paths through the function body do not have a `return` statement and add a `return` statement on those paths. Often the result details show a sequence of events that indicate this execution path. You can add a `return` statement at an appropriate point in the path. If the result details do not show

the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Missing or invalid return statement error

```
int AddSquares(int n)
 {
   int i=0;
   int sum=0;

   if(n!=0)
    {
     for(i=1;i<=n;i++)
        {
         sum+=i^2;
        }
     return(sum);
    }
 }
/* Defect: No return value if n is not 0*/
```

If `n` is equal to 0, the code does not enter the `if` statement. Therefore, the function `AddSquares` does not return a value if `n` is 0.

Correction — Place Return Statement on Every Execution Path

One possible correction is to return a value in every branch of the `if...else` statement.

```
 int AddSquares(int n)
 {
   int i=0;
   int sum=0;

   if(n!=0)
    {
     for(i=1;i<=n;i++)
        {
         sum+=i^2;
        }
```

```
    return(sum);
   }

  /*Fix: Place a return statement on branches of if-else */
  else
    return 0;
 }
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

MSC37-C

Introduced in R2019a

CERT C++: MSC38-C

Do not treat a predefined identifier as an object if it might only be implemented as a macro

Description

Rule Definition

Do not treat a predefined identifier as an object if it might only be implemented as a macro.

Examples

Predefined macro used as an object

Description

Predefined macro used as an object occurs when you use certain identifiers in a way that requires an underlying object to be present. These identifiers are defined as macros. The C Standard does not allow you to redefine them as objects. You use the identifiers in such a way that macro expansion of the identifiers cannot occur.

For instance, you refer to an external variable `errno`:

```
extern int errno;
```

However, `errno` does not occur as a variable but a macro.

The defect applies to these macros: `assert`, `errno`, `math_errhandling`, `setjmp`, `va_arg`, `va_copy`, `va_end`, and `va_start`. The checker looks for the defect only in source files (not header files).

Risk

The C11 Standard (Sec. 7.1.4) allows you to redefine most macros as objects. To access the object and not the macro in a source file, you do one of these:

- Redeclare the identifier as an external variable or function.
- For function-like macros, enclose the identifier name in parentheses.

If you try to use these strategies for macros that cannot be redefined as objects, an error occurs.

Fix

Do not use the identifiers in such a way that a macro expansion is suppressed.

- Do not redeclare the identifiers as external variables or functions.
- For function-like macros, do not enclose the macro name in parentheses.

Example - Use of `assert` as Function

```
#include<assert.h>
typedef void (*err_handler_func)(int);

extern void demo_handle_err(err_handler_func, int);

void func(int err_code) {
    extern void assert(int);
    demo_handle_err(&(assert), err_code);
}
```

In this example, the `assert` macro is redefined as an external function. When passed as an argument to `demo_handle_err`, the identifier `assert` is enclosed in parentheses, which suppresses use of the `assert` macro.

Correction — Use `assert` as Macro

One possible correction is to directly use the `assert` macro from `assert.h`. A different implementation of the function `demo_handle_err` directly uses the `assert` macro instead of taking the address of an `assert` function.

```
#include<assert.h>
void demo_handle_err(int err_code) {
    assert(err_code == 0);
}

void func(int err_code) {
    demo_handle_err(err_code);
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

MSC38-C

Introduced in R2019a

CERT C++: MSC39-C

Do not call va_arg() on a va_list that has an indeterminate value

Description

Rule Definition

Do not call va_arg() on a va_list that has an indeterminate value.

Examples

Invalid va_list argument

Description

Invalid va_list argument occurs when you use a `va_list` variable as an argument to a function in the `vprintf` group but:

- You do not initialize the variable previously using `va_start` or `va_copy`.
- You invalidate the variable previously using `va_end` and do not reinitialize it.

For instance, you call the function `vsprintf` as `vsprintf (buffer,format, args)`. However, before the function call, you do not initialize the `va_list` variable `args` using either of the following:

- `va_start(args, paramName)`. `paramName` is the last named argument of a variable-argument function. For instance, for the function definition `void func(int n, char c, ...) {}`, `c` is the last named argument.
- `va_copy(args, anotherList)`. `anotherList` is another valid `va_list` variable.

Risk

The behavior of an uninitialized `va_list` argument is undefined. Calling a function with an uninitialized `va_list` argument can cause stack overflows.

Fix

Before using a `va_list` variable as function argument, initialize it with `va_start` or `va_copy`.

Clean up the variable using `va_end` only after all uses of the variable.

Example - `va_list` Variable Used Following Call to `va_end`

```
#include <stdarg.h>
#include <stdio.h>

int call_vfprintf(int line, const char *format, ...) {
    va_list ap;
    int r=0;

    va_start(ap, format);
    r = vfprintf(stderr, format, ap);
    va_end(ap);

    r += vfprintf(stderr, format, ap);
    return r;
}
```

In this example, the `va_list` variable `ap` is used in the `vfprintf` function, after the `va_end` macro is called.

Correction — Call `va_end` After Using `va_list` Variable

One possible correction is to call `va_end` only after all uses of the `va_list` variable.

```
#include <stdarg.h>
#include <stdio.h>

int call_vfprintf(int line, const char *format, ...) {
    va_list ap;
    int r=0;

    va_start(ap, format);
    r = vfprintf(stderr, format, ap);
    r += vfprintf(stderr, format, ap);
    va_end(ap);

    return r;
}
```

Too many va_arg calls for current argument list

Description

Too many va_arg calls for current argument list occurs when the number of calls to `va_arg` exceeds the number of arguments passed to the corresponding variadic function. The analysis raises a defect only when the variadic function is called.

Too many va_arg calls for current argument list does not raise a defect when:

- The number of calls to `va_arg` inside the variadic function is indeterminate. For example, if the calls are from an external source.
- The `va_list` used in `va_arg` is invalid.

Risk

When you call `va_arg` and there is no next argument available in `va_list`, the behavior is undefined. The call to `va_arg` might corrupt data or return an unexpected result.

Fix

Ensure that you pass the correct number of arguments to the variadic function.

Example - No Argument Available When Calling `va_arg`

```
#include <stdarg.h>
#include <stddef.h>
#include <math.h>

/* variadic function defined with
* one named argument 'count'
*/
int variadic_func(int count, ...) {
    int result = -1;
    va_list ap;
    va_start(ap, count);
    if (count > 0) {
        result = va_arg(ap, int);
        count --;
        if (count > 0) {
/* No further argument available
* in va_list when calling va_arg
*/
```

```
            result += va_arg(ap, int);
        }
    }
    va_end(ap);
    return result;
}

void func(void) {

    (void)variadic_func(2, 100);

}
```

In this example, the named argument and only one variadic argument are passed to `variadic_func()` when it is called inside `func()`. On the second call to `va_arg`, no further variadic argument is available in `ap` and the behavior is undefined.

Correction — Pass Correct Number of Arguments to Variadic Function

One possible correction is to ensure that you pass the correct number of arguments to the variadic function.

```
#include <stdarg.h>
#include <stddef.h>
#include <math.h>

/* variadic function defined with
* one named argument 'count'
*/

int variadic_func(int count, ...) {
    int result = -1;
    va_list ap;
    va_start(ap, count);
    if (count > 0) {
        result = va_arg(ap, int);
        count --;
        if (count > 0) {

/* The correct number of arguments is
* passed to va_list when variadic_func()
* is called inside func()
*/
```

```
            result += va_arg(ap, int);
        }
    }
    va_end(ap);
    return result;
}

void func(void) {

    (void)variadic_func(2, 100, 200);

}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

MSC39-C

Introduced in R2019a

CERT C++: MSC40-C

Do not violate constraints

Description

Rule Definition

Do not violate constraints.

Examples

Inline constraint not respected

Description

Inline constraint not respected occurs when you refer to a file scope modifiable static variable or define a local modifiable static variable in a nonstatic inlined function. The checker considers a variable as modifiable if it is not `const`-qualified.

For instance, `var` is a modifiable `static` variable defined in an `inline` function `func`. `g_step` is a file scope modifiable static variable referred to in the same inlined function.

```
static int g_step;
inline void func (void) {
   static int var = 0;
   var += g_step;
}
```

Risk

When you modify a static variable in multiple function calls, you expect to modify the same variable in each call. For instance, each time you call `func`, the same instance of `var1` is incremented but a separate instance of `var2` is incremented.

```
void func(void) {
   static var1 = 0;
```

```
   var2 = 0;
   var1++;
   var2++;
}
```

If a function has an inlined and non-inlined definition (in separate files), when you call the function, the C standard allows compilers to use either the inlined or the non-inlined form (see ISO/IEC 9899:2011, sec. 6.7.4). If your compiler uses an inlined definition in one call and the non-inlined definition in another, you are no longer modifying the same variable in both calls. This behavior defies the expectations from a static variable.

Fix

Use one of these fixes:

- If you do not intend to modify the variable, declare it as `const`.

  If you do not modify the variable, there is no question of unexpected modification.
- Make the variable non-`static`. Remove the `static` qualifier from the declaration.

  If the variable is defined in the function, it becomes a regular local variable. If defined at file scope, it becomes an extern variable. Make sure that this change in behavior is what you intend.
- Make the function `static`. Add a `static` qualifier to the function definition.

  If you make the function `static`, the file with the inlined definition always uses the inlined definition when the function is called. Other files use another definition of the function. The question of which function definition gets used is not left to the compiler.

Example - Static Variable Use in Inlined and External Definition

```
/* file1. c  : contains inline definition of get_random()*/

inline unsigned int get_random(void)
{

    static unsigned int m_z = 0xdeadbeef;
    static unsigned int m_w = 0xbaddecaf;

    /* Compute next pseudorandom value and update seeds */
    m_z = 36969 * (m_z & 65535) + (m_z >> 16);
    m_w = 18000 * (m_w & 65535) + (m_w >> 16);
    return (m_z << 16) + m_w;
```

```
}


int call_get_random(void)
{
    unsigned int rand_no;
    int ii;
    for (ii = 0; ii < 100; ii++) {
         rand_no = get_random();
    }
    rand_no = get_random();
    return 0;
}

/* file2. c  : contains external definition of get_random()*/

extern unsigned int get_random(void)
{
    /* Initialize seeds */
    static unsigned int m_z = 0xdeadbeef;
    static unsigned int m_w = 0xbaddecaf;

    /* Compute next pseudorandom value and update seeds */
    m_z = 36969 * (m_z & 65535) + (m_z >> 16);
    m_w = 18000 * (m_w & 65535) + (m_w >> 16);
    return (m_z << 16) + m_w;
}
```

In this example, `get_random()` has an inline definition in `file1.c` and an external definition in `file2.c`. When `get_random` is called in `file1.c`, compilers are free to choose whether to use the inline or the external definition.

Depending on the definition used, you might or might not modify the version of `m_z` and `m_w` in the inlined version of `get_random()`. This behavior contradicts the usual expectations from a static variable. When you call `get_random()`, you expect to always modify the same `m_z` and `m_w`.

Correction — Make Inlined Function Static

One possible correction is to make the inlined `get_random()` static. Irrespective of your compiler, calls to `get_random()` in `file1.c` then use the inlined definition. Calls to `get_random()` in other files use the external definition. This fix removes the ambiguity about which definition is used and whether the static variables in that definition are modified.

```
/* file1. c  : contains inline definition of get_random()*/

static inline unsigned int get_random(void)
{

    static unsigned int m_z = 0xdeadbeef;
    static unsigned int m_w = 0xbaddecaf;

    /* Compute next pseudorandom value and update seeds */
    m_z = 36969 * (m_z & 65535) + (m_z >> 16);
    m_w = 18000 * (m_w & 65535) + (m_w >> 16);
    return (m_z << 16) + m_w;
}


int call_get_random(void)
{
    unsigned int rand_no;
    int ii;
    for (ii = 0; ii < 100; ii++) {
         rand_no = get_random();
    }
    rand_no = get_random();
    return 0;
}

/* file2. c  : contains external definition of get_random()*/

extern unsigned int get_random(void)
{
    /* Initialize seeds */
    static unsigned int m_z = 0xdeadbeef;
    static unsigned int m_w = 0xbaddecaf;

    /* Compute next pseudorandom value and update seeds */
    m_z = 36969 * (m_z & 65535) + (m_z >> 16);
    m_w = 18000 * (m_w & 65535) + (m_w >> 16);
    return (m_z << 16) + m_w;
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

MSC40-C

Introduced in R2019a

CERT C++: MSC50-CPP

Do not use std::rand() for generating pseudorandom numbers

Description

Rule Definition

Do not use std::rand() for generating pseudorandom numbers.

Examples

Vulnerable pseudo-random number generator

Description

The **Vulnerable pseudo-random number generator** identifies uses of cryptographically weak pseudo-random number generator (PRNG) routines.

The list of cryptographically weak routines flagged by this checker include:

- `rand`, `random`
- `drand48`, `lrand48`, `mrand48`, `erand48`, `nrand48`, `jrand48`, and their `_r` equivalents such as `drand48_r`
- `RAND_pseudo_bytes`

Risk

These cryptographically weak routines are predictable and must not be used for security purposes. When a predictable random value controls the execution flow, your program is vulnerable to malicious attacks.

Fix

Use more cryptographically sound random number generators, such as `CryptGenRandom` (Windows), `OpenSSL/RAND_bytes`(Linux/UNIX).

Example - Random Loop Numbers

```
#include <stdio.h>
#include <stdlib.h>

volatile int rd = 1;
int main(int argc, char *argv[])
{
    int j, r, nloops;
    struct random_data buf;
    int i = 0;

    nloops = rand();

    for (j = 0; j < nloops; j++) {
        if (random_r(&buf, &i))
            exit(1);
        printf("random_r: %ld\n", (long)i);
    }
    return 0;
}
```

This example uses `rand` and `random_r` to generate random numbers. If you use these functions for security purposes, these PRNGs can be the source of malicious attacks.

Correction — Use Stronger PRNG

One possible correction is to replace the vulnerable PRNG with a stronger random number generator.

```
#include <stdio.h>
#include <stdlib.h>
#include <openssl/rand.h>

volatile int rd = 1;
int main(int argc, char* argv[])
{
    int j, r, nloops;
    unsigned char buf;
    unsigned int seed;
    int i = 0;

    if (argc != 3)
```

```
    {
        fprintf(stderr, "Usage: %s <seed> <nloops>\n", argv[0]);
        exit(EXIT_FAILURE);
    }

    seed = atoi(argv[1]);
    nloops = atoi(argv[2]);

    for (j = 0; j < nloops; j++) {
        if (RAND_bytes(&buf, i) != 1)
            exit(1);
        printf("RAND_bytes: %u\n", (unsigned)buf);
    }
    return 0;
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

MSC50-CPP

Introduced in R2019a

CERT C++: MSC51-CPP

Ensure your random number generator is properly seeded

Description

Rule Definition

Ensure your random number generator is properly seeded.

Examples

Deterministic random output from constant seed

Description

Deterministic random output from constant seed detects random standard functions that when given a constant seed, have deterministic output.

Risk

When some random functions, such as `srand`, `srandom`, and `initstate`, have constant seeds, the results produce the same output every time that your program is run. A hacker can disrupt your program if they know how your program behaves.

Fix

Use a different random standard function or use a nonconstant seed.

Some standard random routines are inherently cryptographically weak on page 1-885, and should not be used for security purposes.

Example - Random Number Generator Initialization

```
#include <stdlib.h>
```

```
void random_num(void)
{
    srand(12345U);
    /* ... */
}
```

This example initializes a random number generator using `srand` with a constant seed. The random number generation is deterministic, making this function cryptographically weak.

Correction — Use Different Random Number Generator

One possible correction is to use a random number generator that does not require a seed. This example uses `rand_s`.

```
#define _CRT_RAND_S
#include <stdlib.h>
#include <stdio.h>

unsigned int random_num_time(void)
{

    unsigned int number;
    errno_t err;
    err = rand_s(&number);

    if(err != 0)
    {
        return number;
    }
    else
    {
        return err;
    }
}
```

Predictable random output from predictable seed

Description

Predictable random output from predictable seed looks for random standard functions that use a nonconstant but predictable seed. Examples of predictable seed generators are `time`, `gettimeofday`, and `getpid`.

Risk

When you use predictable seed values for random number generation, your random numbers are also predictable. A hacker can disrupt your program if they know how your program behaves.

Fix

You can use a different function to generate less predictable seeds.

You can also use a different random number generator that does not require a seed. For example, the Windows API function `rand_s` seeds itself by default. It uses information from the entire system, for example, system time, thread ids, system counter, and memory clusters. This information is more random and a user cannot access this information.

Some standard random routines are inherently cryptographically weak on page 1-885, and should not be used for security purposes.

Example - Seed as an Argument

```
#include <stdlib.h>
#include <time.h>

void seed_rng(int seed)
{
    srand(seed);
}

int generate_num(void)
{
    seed_rng(time(NULL) + 3);
    /* ... */
}
```

This example uses `srand` to start the random number generator with `seed` as the seed. However, `seed` is predictable because the function `time` generates it. So, an attacker can predict the random numbers generated by `srand`.

Correction — Use Different Random Number Generator

One possible correction is to use a random number generator that does not require a seed. This example uses `rand_s`.

```
#define _CRT_RAND_S

#include <stdlib.h>
#include <stdio.h>
#include <errno.h>

int generate_num(void)
{
    unsigned int number;
    errno_t err;
    err = rand_s(&number);

    if(err != 0)
    {
        return number;
    }
    else
    {
        return err;
    }
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

MSC51-CPP

Introduced in R2019a

CERT C++: MSC52-CPP

Value-returning functions must return a value from all exit paths

Description

Rule Definition

Value-returning functions must return a value from all exit paths.

Examples

Missing return statement

Description

Missing return statement occurs when a function does not return a value along at least one execution path. If the return type of the function is `void`, this error does not occur.

Risk

If a function has a non-`void` return value in its signature, it is expected to return a value. The return value of this function can be used in later computations. If the execution of the function body goes through a path where a `return` statement is missing, the function return value is indeterminate. Computations with this return value can lead to unpredictable results.

Fix

In most cases, you can fix this defect by placing the `return` statement at the end of the function body.

Alternatively, you can identify which execution paths through the function body do not have a `return` statement and add a `return` statement on those paths. Often the result details show a sequence of events that indicate this execution path. You can add a `return` statement at an appropriate point in the path. If the result details do not show

the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Missing or invalid return statement error

```
int AddSquares(int n)
 {
   int i=0;
   int sum=0;

   if(n!=0)
    {
     for(i=1;i<=n;i++)
        {
         sum+=i^2;
        }
     return(sum);
    }
 }
/* Defect: No return value if n is not 0*/
```

If `n` is equal to 0, the code does not enter the `if` statement. Therefore, the function `AddSquares` does not return a value if `n` is 0.

Correction — Place Return Statement on Every Execution Path

One possible correction is to return a value in every branch of the `if...else` statement.

```
 int AddSquares(int n)
 {
   int i=0;
   int sum=0;

   if(n!=0)
    {
     for(i=1;i<=n;i++)
        {
         sum+=i^2;
        }
```

```
    return(sum);
   }

  /*Fix: Place a return statement on branches of if-else */
  else
    return 0;
 }
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

MSC52-CPP

Introduced in R2019a

CERT C++: PRE30-C

Do not create a universal character name through concatenation

Description

Rule Definition

Do not create a universal character name through concatenation.

Examples

Universal character name from token concatenation

Description

Universal character name from token concatenation occurs when two preprocessing tokens joined with a ## operator create a universal character name. A universal character name begins with `\u` or `\U` followed by hexadecimal digits. It represents a character not found in the basic character set.

For instance, you form the character `\u0401` by joining two tokens:

```
#define assign(uc1, uc2, val) uc1##uc2 = val
...
assign(\u04, 01, 4);
```

Risk

The C11 Standard (Sec. 5.1.1.2) states that if a universal character name is formed by token concatenation, the behavior is undefined.

Fix

Use the universal character name directly instead of producing it through token concatenation.

Example - Universal Character Name from Token Concatenation

```
#define assign(uc1, uc2, val) uc1##uc2 = val

int func(void) {
    int \u0401 = 0;
    assign(\u04, 01, 4);
    return \u0401;
}
```

In this example, the `assign` macro, when expanded, joins the two tokens `\u04` and `01` to form the universal character name `\u0401`.

Correction — Use Universal Character Name Directly

One possible correction is to use the universal character name `\u0401` directly. The correction redefines the `assign` macro so that it does not join tokens.

```
#define assign(ucn, val) ucn = val

int func(void) {
    int \u0401 = 0;
    assign(\u0401, 4);
    return \u0401;
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

PRE30-C

Introduced in R2019a

CERT C++: PRE31-C

Avoid side effects in arguments to unsafe macros

Description

Rule Definition

Avoid side effects in arguments to unsafe macros.

Examples

Side effect in arguments to unsafe macro

Description

Side effect in arguments to unsafe macro occurs when you call an unsafe macro with an expression that has a side effect.

- *Unsafe macro*: When expanded, an unsafe macro evaluates its arguments multiple times or does not evaluate its argument at all.

  For instance, the `ABS` macro evaluates its argument `x` twice.

  ```
  #define ABS(x) (((x) < 0) ? -(x) : (x))
  ```

- *Side effect*: When evaluated, an expression with a side effect modifies at least one of the variables in the expression.

  For instance, `++n` modifies `n`, but `n+1` does not modify `n`.

  The checker does not consider side effects in nested macros. The checker also does not consider function calls or volatile variable access as side effects.

Risk

If you call an unsafe macro with an expression that has a side effect, the expression is evaluated multiple times or not evaluated at all. The side effect can occur multiple times or not occur at all, causing unexpected behavior.

For instance, in the call `MACRO(++n)`, you expect only one increment of the variable `n`. If `MACRO` is an unsafe macro, the increment happens more than once or does not happen at all.

The checker flags expressions with side effects in the `assert` macro because the `assert` macro is disabled in non-debug mode. To compile in non-debug mode, you define the `NDEBUG` macro during compilation. For instance, in GCC, you use the flag `-DNDEBUG`.

Fix

Evaluate the expression with a side effect in a separate statement, and then use the result as a macro argument.

For instance, instead of:

```
MACRO(++n);
```

perform the operation in two steps:

```
++n;
MACRO(n);
```

Alternatively, use an inline function instead of a macro. Pass the expression with side effect as argument to the inline function.

The checker considers modifications of a local variable defined only in the block scope of a macro body as a side effect. This defect cannot happen since the variable is visible only in the macro body. If you see a defect of this kind, ignore the defect.

Example - Macro Argument with Side Effects

```
#define ABS(x) (((x) < 0) ? -(x) : (x))

void func(int n) {
  /* Validate that n is within the desired range */
  int m = ABS(++n);
```

```
  /* ... */
}
```

In this example, the ABS macro evaluates its argument twice. The second evaluation can result in an unintended increment.

Correction — Separate Evaluation of Expression from Macro Usage

One possible correction is to first perform the increment, and then pass the result to the macro.

```
#define ABS(x) (((x) < 0) ? -(x) : (x))

void func(int n) {
  /* Validate that n is within the desired range */
  ++n;
  int m = ABS(n);

  /* ... */
}
```

Correction — Evaluate Expression in Inline Function

Another possible correction is to evaluate the expression in an inline function.

```
static inline int iabs(int x) {
  return (((x) < 0) ? -(x) : (x));
}

void func(int n) {
  /* Validate that n is within the desired range */

int m = iabs(++n);

  /* ... */
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

PRE31-C

Introduced in R2019a

CERT C++: PRE32-C

Do not use preprocessor directives in invocations of function-like macros

Description

Rule Definition

Do not use preprocessor directives in invocations of function-like macros.

Examples

Preprocessor directive in macro argument

Description

Preprocessor directive in macro argument occurs when you use a preprocessor directive in the argument to a function-like macro or a function that might be implemented as a function-like macro.

For instance, a `#ifdef` statement occurs in the argument to a `memcpy` function. The `memcpy` function might be implemented as a macro.

```
memcpy(dest, src,
    #ifdef PLATFORM1
      12
    #else
      24
    #endif
  );
```

The checker flags similar usage in `printf` and `assert`, which can also be implemented as macros.

Risk

During preprocessing, a function-like macro call is replaced by the macro body and the parameters are replaced by the arguments to the macro call (argument substitution). Suppose a macro `min()` is defined as follows.

```
#define min(X, Y)  ((X) < (Y) ? (X) : (Y))
```

When you call `min(1,2)`, it is replaced by the body `((X) < (Y) ? (X) : (Y))`. `X` and `Y` are replaced by 1 and 2.

According to the C11 Standard (Sec. 6.10.3), if the list of arguments to a function-like macro itself has preprocessing directives, the argument substitution during preprocessing is undefined.

Fix

To ensure that the argument substitution happens in an unambiguous manner, use the preprocessor directives outside the function-like macro.

For instance, to execute `memcpy` with different arguments based on a `#ifdef` directive, call `memcpy` multiple times within the `#ifdef` directive branches.

```
#ifdef PLATFORM1
    memcpy(dest, src, 12);
#else
    memcpy(dest, src, 24);
#endif
```

Example - Directives in Function-Like Macros

```
#include <stdio.h>

#define print(A) printf(#A)

void func(void) {
    print(
#ifdef SW
          "Message 1"
#else
          "Message 2"
#endif
         );
}
```

In this example, the preprocessor directives `#ifdef` and `#endif` occur in the argument to the function-like macro `print()`.

Correction — Use Directives Outside Macro

One possible correction is to use the function-like macro multiple times in the branches of the `#ifdef` directive.

```
#include <stdio.h>

#define print(A) printf(#A)

void func(void) {
#ifdef SW
        print("Message 1");
#else
        print("Message 2");
#endif
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

PRE32-C

Introduced in R2019a

CERT C++: SIG31-C

Do not access shared objects in signal handlers

Description

Rule Definition

Do not access shared objects in signal handlers.

Examples

Shared data access within signal handler

Description

Shared data access within signal handler occurs when you access or modify a shared object inside a signal handler.

Risk

When you define a signal handler function to access or modify a shared object, the handler accesses or modifies the shared object when it receives a signal. If another function is already accessing the shared object, that function causes a race condition and can leave the data in an inconsistent state.

Fix

To access or modify shared objects inside a signal handler, check that the objects are lock-free atomic, or, if they are integers, declare them as `volatile sig_atomic_t`.

Example - `int` Variable Access in Signal Handler

```
#include <signal.h>
#include <stdlib.h>
#include <string.h>
```

```
/* declare global variable. */
int e_flag;

void sig_handler(int signum)
{
    /* Signal handler accesses variable that is not
    of type volatile sig_atomic_t. */
    e_flag = signum;
}

int func(void)
{
    if (signal(SIGINT, sig_handler) == SIG_ERR)
    {
        /* Handle error */
        abort();
    }
    /* Program code */
    if (raise(SIGINT) != 0)
    {
        /* Handle error */
        abort();
    }
    /* More code */
    return 0;
}
```

In this example, `sig_handler` accesses `e_flag`, a variable of type `int`. A concurrent access by another function can leave `e_flag` in an inconsistent state.

Correction — Declare Variable of Type `volatile sig_atomic_t`

Before you access a shared variable from a signal handler, declare the variable with type `volatile sig_atomic_t` instead of `int`. You can safely access variables of this type asynchronously.

```
#include <signal.h>
#include <stdlib.h>
#include <string.h>

/* Declare variable of type volatile sig_atomic_t. */
```

```
volatile sig_atomic_t e_flag;
void sig_handler(int signum)
{
    /* Use variable of proper type inside signal handler. */
    e_flag = signum;

}

int func(void)
{
    if (signal(SIGINT, sig_handler) == SIG_ERR)
    {
        /* Handle error */
        abort();
    }
    /* Program code */
    if (raise(SIGINT) != 0)
    {
        /* Handle error */
        abort();
    }
    /* More code */
    return 0;
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

SIG31-C

Introduced in R2019a

CERT C++: SIG34-C

Do not call signal() from within interruptible signal handlers

Description

Rule Definition

Do not call signal() from within interruptible signal handlers.

Examples

Signal call from within signal handler

Description

Signal call from within signal handler occurs when you call `signal()` from a nonpersistent signal handler on a Windows platform.

Risk

A nonpersistent signal handler is reset after catching a signal. The handler does not catch subsequent signals unless the handler is reestablished by calling `signal()`. A nonpersistent signal handler on a Windows platform is reset to `SIG_DFL`. If another signal interrupts the execution of the handler, that signal can cause a race condition between `SIG_DFL` and the existing signal handler. A call to `signal()` can also result in an infinite loop inside the handler.

Fix

Do not call `signal()` from a signal handler on Windows platforms.

Example - `signal()` Called from Signal Handler

```
#include <stdio.h>
#include <stdlib.h>
```

```
#include <signal.h>
#include <unistd.h>



volatile sig_atomic_t e_flag = 0;

void sig_handler(int signum)
{
    int s0 = signum;
    e_flag = 1;

    /* Call signal() to reestablish sig_handler
    upon receiving SIG_ERR. */

    if (signal(s0, sig_handler) == SIG_ERR)
    {
        /* Handle error */
    }
}

void func(void)
{
        if (signal(SIGINT, sig_handler) == SIG_ERR)
        {
            /* Handle error */

        }
  /* more code */
}
```

In this example, the definition of `sig_handler()` includes a call to `signal()` when the handler catches `SIG_ERR`. On Windows platforms, signal handlers are nonpersistent. This code can result in a race condition.

Correction — Do Not Call `signal()` from Signal Handler

If your code requires the use of a persistent signal handler on a Windows platform, use a persistent signal handler after performing a thorough risk analysis.

```
#include <stdio.h>
#include <stdlib.h>
#include <signal.h>
```

```
#include <unistd.h>


volatile sig_atomic_t e_flag = 0;


void sig_handler(int signum)
{
    int s0 = signum;
    e_flag = 1;
    /* No call to signal() */
}

int main(void)
{

        if (signal(SIGINT, sig_handler) == SIG_ERR)
        {
            /* Handle error */

        }
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

SIG34-C

Introduced in R2019a

CERT C++: SIG35-C

Do not return from a computational exception signal handler

Description

Rule Definition

Do not return from a computational exception signal handler.

Examples

Return from computational exception signal handler

Description

Return from computational exception signal handler occurs when a signal handler returns after catching a computational exception signal `SIGFPE`, `SIGILL`, or `SIGSEGV`.

Risk

A signal handler that returns normally from a computational exception is undefined behavior. Even if the handler attempts to fix the error that triggered the signal, the program can behave unexpectedly.

Fix

Check the validity of the values of your variables before the computation to avoid using a signal handler to catch exceptions. If you cannot avoid a handler to catch computation exception signals, call `abort()`, `quick_exit()`, or `_Exit()` in the handler to stop the program.

Example - Signal Handler Return from Division by Zero

```
#include <errno.h>
#include <limits.h>
```

```
#include <signal.h>
#include <stdlib.h>

static volatile sig_atomic_t denom;
/* Declare signal handler to catch division by zero
computation error. */
void sig_handler(int s)
{
    int s0 = s;
    if (denom == 0)
    {
        denom = 1;
    }
    /* Normal return from computation exception
    signal */
    return;
}


long func(int v)
{
    denom = (sig_atomic_t)v;

        if (signal(SIGFPE, sig_handler) == SIG_ERR)
        {
            /* Handle error */
        }

    long result = 100 / (long)denom;
    return result;
}
```

In this example, `sig_handler` is declared to handle a division by zero computation error. The handler changes the value of `denom` if it is zero and returns, which is undefined behavior.

Correction — Call `abort()` to Terminate Program

After catching a computational exception, call `abort()` from `sig_handler` to exit the program without further error.

```
#include <errno.h>
#include <limits.h>
```

```
#include <signal.h>
#include <stdlib.h>

static volatile sig_atomic_t denom;
/* Declare signal handler to catch division by zero
computation error. */

void sig_handler(int s)
{
    int s0 = s;
    /* call to abort() to exit the program */
    abort();
}

long func(int v)
{
    denom = (sig_atomic_t)v;

        if (signal(SIGFPE, sig_handler) == SIG_ERR)
        {
            /* Handle error */
        }

    long result = 100 / (long)denom;
    return result;
}
```

Check Information

Group: 49. Miscellaneous (MSC)

See Also

External Websites

SIG35-C

Introduced in R2019a

AUTOSAR C++14 Rules

AUTOSAR C++14 Rule A0-1-2

The value returned by a function having a non-void return type that is not an overloaded operator shall be used.

Description

Rule Definition

The value returned by a function having a non- void return type that is not an overloaded operator shall always be used.

Rationale

The unused return value might indicate a coding error or oversight.

Overloaded operators are excluded from this rule because their usage must emulate built-in operators which might not use their return value.

Polyspace Implementation

Bug Finder and Code Prover check this coding rule differently. The analyses can produce different results.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Return Value Not Used

```
#include <iostream>
#include <new>
```

```
int assignMemory(int * ptr){
     int res = 1;
     ptr = new (std::nothrow) int;
     if(ptr==NULL) {
         res = 0;
     }
     return res;
}

void main() {
    int val;
    int status;

    assignMemory(&val);   //Noncompliant
    status = assignMemory(&val); //Compliant
    (void)assignMemory(&val); //Compliant

}
```

The first call to the function `assignMemory` is noncompliant because the return value is not used. The second and third calls use the return value. The return value from the second call is assigned to a local variable.

The return value from the third call is cast to `void`. Casting to `void` indicates deliberate non-use of the return value and cannot be a coding oversight.

Check Information

Group: Language Independent Issues

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A0-1-6

There should be no unused type declarations.

Description

Rule Definition

A project shall not contain unused type declarations.

Rationale

If a type is declared but not used, when reviewing the code later, it is unclear if the type is redundant or left unused by mistake.

Unused types can indicate coding errors. For instance, you declared a enumerated data type for some specialized data but used an integer type for the data.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Unused `enum` Declaration

```
enum switchValue {low, medium, high}; //Noncompliant

void operate(int userInput) {
    switch(userInput) {
        case 0: // Turn on low setting
                 break;
        case 1: // Turn on medium setting
                 break;
```

```
        case 2: // Turn on high setting
                 break;
        default: // Return error
    }
}
```

In this example, the enumerated type `switchValue` is not used. Perhaps the intention was to use the type as `switch` input like this.

```
enum switchValue {low, medium, high}; //Compliant

void operate(switchValue userInput) {
    switch(userInput) {
        case low: // Turn on low setting
                   break;
        case medium: // Turn on medium setting
                     break;
        case high: // Turn on high setting
                   break;
        default: // Return error
    }
}
```

Check Information

Group: Language Independent Issues

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A0-4-2

Type long double shall not be used

Description

Rule Definition

Type long double shall not be used.

Rationale

The size of `long double` is implementation-dependent and reduces the portability of your code across compilers. Compilers can implement `long double` as a synonym for `double` or an 80-bit extended precision type or 128-bit quadruple precision type that are more precise than `double`.

Instead, for multiple precision arithmetic that requires types more precise than `double`, use libraries that support multiple precision arithmetic with well-defined data types.

Polyspace Implementation

The rule checker flags all uses of the `long double` keyword.

If you do not want to fix the issue, add a comment justifying the result. See “Address Polyspace Results Through Bug Fixes or Comments”.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of `long double` Keyword

```
void func() {
  float f{0.1F};  //Compliant
  double D(0.1);  //Compliant
  long double LD(0.1L);  //Noncompliant
}
```

The use of `long double` violates this rule.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A10-2-1

Non-virtual member functions shall not be redefined in derived classes.

Description

Rule Definition

Non-virtual member functions shall not be redefined in derived classes.

Polyspace Implementation

Does not report for destructor.

Message in report file:

Inherited nonvirtual function `%s` shall not be redefined in a derived class.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A1-1-1

All code shall conform to ISO/IEC 14882:2014 - Programming Language C++ and shall not use deprecated features.

Description

Rule Definition

All code shall conform to ISO/IEC 14882:2003 "The C++ Standard Incorporating Technical Corrigendum 1".

Polyspace Implementation

The checker reports compilation errors as detected by a compiler that strictly adheres to the C++03 Standard (ISO/IEC 14882:2003).

Bug Finder and Code Prover check this coding rule differently. The analyses can produce different results.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: General

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A11-3-1

Friend declarations shall not be used

Description

Rule Definition

Friend declarations shall not be used.

Rationale

You declare a function as friend of a class to access private members of the class outside the class scope.

```
class A
{
  int data;
  public:
    // operator+ can access private members of class A such as data
    friend A const operator+(A const& lhs, A const& rhs);
};
```

Friend functions and friend classes reduce data encapsulation. Private members of a class are no longer accessible only through the class methods.

Code with friend functions can be difficult to maintain. For instance, if class `myClass` has a friend class `anotherClass`, when you change a data member of `myClass`, you have to find all instances of its usage in member functions of `anotherClass`.

Polyspace Implementation

The rule checker flags all uses of the `friend` keyword.

The checker follows specifications of AUTOSAR C++ 14 release 18-03 (March 2018). However, release 18-10 and later releases of AUTOSAR C++14 allows an exception for comparison operators such as `operator==`. If the rule checker flags the use of

comparison operators, add a comment justifying the result. See “Address Polyspace Results Through Bug Fixes or Comments”.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of `friend` Keyword

```
class myClass
{
  int data;
  public:
    myClass& operator+=(myClass const& oth);
    friend myClass const operator+(myClass const& lhs, myClass const& rhs);
    // Noncompliant: Use of friend keyword
};
```

`operator+` is a friend function of class `myClass` and can access its private member, `data`. The presence of this friend function violates the rule.

Check Information

Group: Member Access Control

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A12-1-1

Constructors shall explicitly initialize all virtual base classes, all direct non-virtual base classes and all non-static data members.

Description

Rule Definition

All constructors of a class should explicitly call a constructor for all of its immediate base classes and all virtual base classes.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Special Member Functions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A12-1-4

All constructors that are callable with a single argument of fundamental type shall be declared explicit.

Description

Rule Definition

All constructors that are callable with a single argument of fundamental type shall be declared explicit.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Special Member Functions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A12-6-1

All class data members that are initialized by the constructor shall be initialized using member initializers.

Description

Rule Definition

All class data members that are initialized by the constructor shall be initialized using member initializers.

Polyspace Implementation

All data should be initialized in the initialization list except for array. Does not report that an assignment exists in `ctor` body.

Message in report file:

Initialization of nonstatic class members "*<field>*" will be performed through the member initialization list.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A12-8-5

A copy assignment and a move assignment operators shall handle self-assignment.

Description

Rule Definition

A copy assignment and a move assignment operators shall handle self-assignment.

Polyspace Implementation

Reports when copy assignment body does not begin with "`if (this != arg)`"

A violation is not raised if an empty `else` statement follows the `if`, or the body contains only a return statement.

A violation is raised when the `if` statement is followed by a statement other than the return statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A13-2-1

An assignment operator shall return a reference to "this".

Description

Rule Definition

An assignment operator shall return a reference to "this".

Polyspace Implementation

The following operators should return `*this` on method, and `*first_arg` on plain function.

```
operator=operator+=operator-=operator*=operator >>=operator
<<=operator /=operator %=operator |=operator &=operator ^=prefix
operator++prefix operator--
```

Does not report when no return exists.

No special message if type does not match.

Messages in report file:

- An assignment operator shall return a reference to `*this`.
- An assignment operator shall return a reference to its first arg.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A15-1-2

An exception object shall not be a pointer.

Description

Rule Definition

An exception object should not have pointer type.

Polyspace Implementation

The checker raises a violation if a `throw` statement throws an exception of pointer type.

The checker does not raise a violation if a NULL pointer is thrown as exception. Throwing a NULL pointer is forbidden by `AUTOSAR C++14 Rule M15-1-2`.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A15-3-5

A class type exception shall be caught by reference or const reference.

Description

Rule Definition

A class type exception shall always be caught by reference.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A15-5-3

The std::terminate() function shall not be called implicitly.

Description

Rule Definition

The terminate() function shall not be called implicitly.

Polyspace Implementation

The checker flags these situations when the terminate() function can be called implicitly:

- An exception escapes uncaught. For instance:
  - Before an exception is caught, it escapes through another function that throws an uncaught exception. For instance, a catch statement or exception handler invokes a copy constructor that throws an uncaught exception.
  - A throw expression with no operand rethrows an uncaught exception.
- A class destructor throws an exception.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A16-2-1

The ', ", /*, //, \ characters shall not occur in a header file name or in #include directive.

Description

Rule Definition

The ', ", / or // characters shall not occur in a header file name.*

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A17-0-1

Reserved identifiers, macros and functions in the C++ standard library shall not be defined, redefined or undefined.

Description

Rule Definition

Reserved identifiers, macros and functions in the standard library shall not be defined, redefined or undefined.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Library Introduction

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A18-0-1

The C library facilities shall only be accessed through C++ library headers.

Description

Rule Definition

The C library shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Language Support Library

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A18-0-2

The error state of a conversion from string to a numeric value shall be checked.

Description

Rule Definition

The library functions atof, atoi and atol from library <cstdlib> shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Language Support Library

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A18-0-3

The library <clocale> (locale.h) and the setlocale function shall not be used.

Description

Rule Definition

The library <clocale> (locale.h) and the setlocale function shall not be used.

Polyspace Implementation

`setlocale` and `localeconv` should not be used as a macro or a global with external "C" linkage.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A18-5-3

The form of delete operator shall match the form of new operator used to allocate the memory

Description

Rule Definition

The form of delete operator shall match the form of new operator used to allocate the memory.

Rationale

- The `delete` operator releases a block of memory allocated on the heap. If you try to access a location on the heap that you did not allocate previously, a segmentation fault can occur.
- If you use the single-object notation for `delete` on a pointer that is previously allocated with the array notation for `new`, the behavior is undefined.

The issue can also highlight other coding errors. For instance, you perhaps wanted to use the `delete` operator or a previous `new` operator on a different pointer.

Polyspace Implementation

The checker flags a defect when:

- You release a block of memory with the `delete` operator but the memory was previously not allocated with the `new` operator.
- You release a block of memory with the `delete` operator using the single-object notation but the memory was previously allocated as an array with the `new` operator.

This defect applies only to C++ source files.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Deleting Static Memory

```
void assign_ones(void)
{
    int ptr[10];

    for(int i=0;i<10;i++)
        *(ptr+i)=1;

    delete[] ptr;
}
```

The pointer `ptr` is released using the `delete` operator. However, `ptr` points to a memory location that was not dynamically allocated.

Correction: Remove Pointer Deallocation

If the number of elements of the array `ptr` is known at compile time, one possible correction is to remove the deallocation of the pointer `ptr`.

```
void assign_ones(void)
{
    int ptr[10];

    for(int i=0;i<10;i++)
        *(ptr+i)=1;
}
```

Correction — Add Pointer Allocation

If the number of array elements is not known at compile time, one possible correction is to dynamically allocate memory to the array `ptr` using the `new` operator.

```
void assign_ones(int num)
{
```

```
    int *ptr = new int[num];

    for(int i=0; i < num; i++)
        *(ptr+i) = 1;

    delete[] ptr;
   }
```

Mismatched `new` and `delete`

```
int main (void)
{
    int *p_scale = new int[5];

    //more code using scal

    delete p_scale;
}
```

In this example, `p_scale` is initialized to an array of size 5 using `new int[5]`. However, `p_scale` is deleted with `delete` instead of `delete[]`. The `new`-`delete` pair does not match. Do not use `delete` without the brackets when deleting arrays.

Correction — Match `delete` to `new`

One possible correction is to add brackets so the `delete` matches the `new []` declaration.

```
int main (void)
{
    int *p_scale = new int[5];

    //more code using p_scale

    delete[] p_scale;
}
```

Correction — Match `new` to `delete`

Another possible correction is to change the declaration of `p_scale`. If you meant to initialize `p_scale` as 5 itself instead of an array of size 5, you must use different syntax. For this correction, change the square brackets in the initialization to parentheses. Leave the `delete` statement as it is.

```
int main (void)
{
    int *p_scale = new int(5);

    //more code using p_scale

    delete p_scale;
}
```

Check Information

Group: Language Support Library

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A18-5-4

If a project has sized or unsized version of operator 'delete' globally defined, then both sized and unsized versions shall be defined.

Description

Rule Definition

If a project has sized or unsized version of operator 'delete' globally defined, then both sized and unsized versions shall be defined.

Rationale

The C++14 Standard defines a sized version of `operator delete`. For instance, for an unsized `operator delete` with this signature:

```
void operator delete (void* ptr);
```

The sized version has an additional size argument:

```
void operator delete (void* ptr, std::size_t size);
```

See the C++ reference page for `operator delete`.

The Standard states that if both versions of `operator delete` exist, the sized version must be called because it provides a more efficient way to deallocate memory, especially when the allocator allocates in size categories instead of storing the size nearbly the object. However, in some cases, for instance to delete incomplete types, the unsized version is used.

If you overload the unsized version of `operator delete`, you must also overload the sized version. You typically overload `operator delete` to perform some bookkeeping in addition to deallocating memory on the free store. If you overload the unsized version but not the sized one or the other way around, any bookkeeping you perform in one version will not omitted from the other version. This omission can lead to unexpected results.

Polyspace Implementation

The checker flags situations where an unsized version of `operator delete` exists but the corresponding sized version is not defined, or vice versa.

The checker is enabled only if you specify a C++ version of C++14 or later. See `C++ standard version (-cpp-version)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Missing Sized Overload of `operator delete[]`

```
#include <new>
#include <cstdlib>

int global_store;

void update_bookkeeping(void *allocated_ptr, bool alloc) {
   if(alloc)
      global_store++;
   else
      global_store--;
}

void operator delete(void *ptr);
void operator delete(void* ptr) {
    update_bookkeeping(ptr, false);
    free(ptr);
}

void operator delete(void *ptr, std::size_t size);
void operator delete(void* ptr, std::size_t size) {
    //Compliant, both sized and unsized version defined
    update_bookkeeping(ptr, false);
```

```
    free(ptr);
}

void operator delete[](void *ptr);
void operator delete[](void* ptr) { //Noncompliant, only unsized version defined
    update_bookkeeping(ptr, false);
    free(ptr);
}
```

In this example, both the unsized and sized version of `operator delete` are overloaded and complies with the rule. However, only the unsized version of `operator delete[]` is overloaded, which violates the rule..

Check Information

Group: Language Support Library

See Also

`Invalid deletion of pointer` | `Invalid free of pointer` | `Memory leak` | `Mismatched alloc/dealloc functions on Windows` | `Missing overload of allocation or deallocation function`

Introduced in R2019a

AUTOSAR C++14 Rule A2-11-1

Volatile keyword shall not be used.

Description

Rule Definition

Volatile keyword shall not be used.

Polyspace Implementation

Reports if volatile keyword is used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A2-13-1

Only those escape sequences that are defined in ISO/IEC 14882:2014 shall be used.

Description

Rule Definition

Only those escape sequences that are defined in ISO/IEC 14882:2003 shall be used.

Rationale

Escape sequences are certain special characters represented in string and character literals. They are written with a backslash (\) followed by a character.

The C++ Standard (ISO/IEC 14882:2003, Sec. 2.13.2) defines a list of escape sequences. See Escape Sequences. Use of escape sequences (backslash followed by character) outside that list leads to undefined behavior.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Incorrect Escape Sequences

```
void func () {
  const char a[2] = "\k"; \\Noncompliant
  const char b[2] = "\b"; \\Compliant
}
```

In this example, `\k` is not a recognized escape sequence.

Check Information

Group: Lexical Conventions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A2-13-2

String literals with different encoding prefixes shall not be concatenated.

Description

Rule Definition

Narrow and wide string literals shall not be concatenated.

Rationale

Narrow string literals are enclosed in double quotes without a prefix. Wide string literals are enclosed in double quotes with a prefix `L` outside the quotes. See string literals.

Concatenation of narrow and wide string literals can lead to undefined behavior.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Concatenation of Narrow and Wide String Literals

```
char array[] = "Hello" "World";
wchar_t w_array[] = L"Hello" L"World";
wchar_t mixed[] = "Hello" L"World"; //Noncompliant
```

In this example, in the initialization of the array `mixed`, the narrow string literal `"Hello"` is concatenated with the wide string literal `L"World"`.

Check Information

Group: Lexical Conventions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A2-13-3

Type wchar_t shall not be used

Description

Rule Definition

Type wchar_t shall not be used.

Rationale

The size of `wchar_t` is implementation-dependent. If you use `wchar_t` for Unicode values, your code is bound to a specific compiler.

To improve the portability of your code, use `char16_t` and `char32_t` instead. These are standard types introduced in C++11 for text strings with UTF-16 and UTF-32 encodings.

Polyspace Implementation

The rule checker flags all uses of the `wchar_t` keyword.

If you do not want to fix the issue, add a comment justifying the result. See “Address Polyspace Results Through Bug Fixes or Comments”.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of `wchar_t` Keyword

```
char16_t str1[] = u"A UTF-16 string";  //Compliant
char32_t str2[] = U"A UTF-32 string";  //Compliant
wchar_t str3[] = L"A Unicode string";  //Noncompliant
```

The use of `wchar_t` violates this rule. Instead the types `char16_t` and `char32_t` can be used.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A2-13-5

Hexadecimal constants should be upper case.

Description

Rule Definition

Hexadecimal constants should be upper case.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A21-8-1

Arguments to character-handling functions shall be representable as an unsigned char.

Description

Rule Definition

Arguments to character-handling functions shall be representable as an unsigned char.

Rationale

Comparison with EOF: Suppose, your compiler implements the plain `char` type as signed. In this implementation, the character with the decimal form of 255 (–1 in two's complement form) is stored as a signed value. When you convert a `char` variable to the wider data type `int` for instance, the sign bit is preserved (sign extension). This sign extension results in the character with the decimal form 255 being converted to the integer –1, which cannot be distinguished from EOF.

Use as array index: By similar reasoning, you cannot use sign-extended plain `char` variables as array index. If the sign bit is preserved, the conversion from `char` to `int` can result in negative integers. You must use positive integer values for array index.

Argument to character-handling function: By similar reasoning, you cannot use sign-extended plain `char` variables as arguments to character-handling functions declared in `ctype.h`, for instance, `isalpha()` or `isdigit()`. According to the C11 standard (Section 7.4), if you supply an integer argument that cannot be represented as `unsigned char` or EOF, the resulting behavior is undefined.

Polyspace Implementation

The check raises a flag when:

- You use invalid arguments with an integer function from the standard library. This check picks up:

  - Character Conversion

    `toupper, tolower`
  - Character Checks

    `isalnum, isalpha, iscntrl, isdigit, isgraph, islower, isprint, ispunct, isspace, isupper, isxdigit`
  - Integer Division

    `div, ldiv`
  - Absolute Values

    `abs, labs`
- You convert a signed or plain `char` data type to a wider integer data type with sign extension. You then use the resulting sign-extended value as array index, for comparison with EOF or as argument to a character-handling function.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Absolute Value of Large Negative

```
#include <limits.h>
#include <stdlib.h>

int absoluteValue(void) {

    int neg = INT_MIN;
    return abs(neg);
}
```

The input value to `abs` is `INT_MIN`. The absolute value of `INT_MIN` is `INT_MAX+1`. This number cannot be represented by the type `int`.

Correction — Change Input Argument

One possible correction is to change the input value to fit returned data type. In this example, change the input value to `INT_MIN+1`.

```
#include <limits.h>
#include <stdlib.h>

int absoluteValue(void) {

    int neg = INT_MIN+1;
    return abs(neg);
}
```

Sign-Extended Character Value Compared with EOF

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

extern char parsed_token_buffer[20];

static int parser(char *buf)
{
    int c = EOF;
    if (buf && *buf) {
        c = *buf++;
    }
    return c;
}

void func()
{
    if (parser(parsed_token_buffer) == EOF) {
        /* Handle error */
        fatal_error();
    }
}
```

In this example, the function `parser` can traverse a string input `buf`. If a character in the string has the value -1, it can represent either `EOF` or the valid character value `'\377'` (corresponding to the `unsigned char` equivalent 255). When converted to the `int` variable `c`, its value becomes the integer value -1, which is always `EOF`. The later comparison with `EOF` will not detect if the value returned from `parser` is actually `EOF`.

Correction — Cast to `unsigned char` Before Conversion

One possible correction is to cast the plain `char` value to `unsigned char` before conversion to the wider `int` type. Only then can you test if the return value of `parser` is really `EOF`.

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

extern char parsed_token_buffer[20];

static int parser(char *buf)
{
    int c = EOF;
    if (buf && *buf) {
        c = (unsigned char)*buf++;
    }
    return c;
}

void func()
{
    if (parser(parsed_token_buffer) == EOF) {
        /* Handle error */
        fatal_error();
    }
}
```

Check Information

Group: Strings library

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A2-5-1

Trigraphs shall not be used.

Description

Rule Definition

Trigraphs shall not be used.

Rationale

You denote trigraphs with two question marks followed by a specific third character (for instance,`'??-'` represents a `'~'` (tilde) character and `'??)'` represents a `']'`). These trigraphs can cause accidental confusion with other uses of two question marks.

For instance, the string

```
"(Date should be in the form ??-??-??)"
```

is transformed to

```
"(Date should be in the form ~~]"
```

but this transformation might not be intended.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Lexical Conventions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A2-5-2

Digraphs shall not be used.

Description

Rule Definition

Digraphs should not be used.

Rationale

Digraphs are a sequence of two characters that are supposed to be treated as a single character. The checker flags use of these digraphs:

- `<%`, indicating `[`
- `%>`, indicating `]`
- `<:`, indicating `{`
- `:>`, indicating `}`
- `%:`, indicating `#`
- `%:%:`

When developing or reviewing code with digraphs, the developer or reviewer can incorrectly consider the digraph as a sequence of separate characters.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Lexical Conventions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A26-5-1

Pseudorandom numbers shall not be generated using `std::rand()`.

Description

Rule Definition

Pseudorandom numbers shall not be generated using `std::rand()`.

Rationale

This cryptographically weak routines is predictable and must not be used for security purposes. When a predictable random value controls the execution flow, your program is vulnerable to malicious attacks.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Random Loop Numbers

```
#include <stdio.h>
#include <stdlib.h>

volatile int rd = 1;
int main(int argc, char *argv[])
{
    int j, r, nloops;
    struct random_data buf;
    int i = 0;
```

```
    nloops = rand();

    for (j = 0; j < nloops; j++) {
        if (random_r(&buf, &i))
            exit(1);
        printf("random_r: %ld\n", (long)i);
    }
    return 0;
}
```

This example uses `rand` and `random_r` to generate random numbers. If you use these functions for security purposes, these PRNGs can be the source of malicious attacks.

Correction — Use Stronger PRNG

One possible correction is to replace the vulnerable PRNG with a stronger random number generator.

```
#include <stdio.h>
#include <stdlib.h>
#include <openssl/rand.h>

volatile int rd = 1;
int main(int argc, char* argv[])
{
    int j, r, nloops;
    unsigned char buf;
    unsigned int seed;
    int i = 0;

    if (argc != 3)
    {
        fprintf(stderr, "Usage: %s <seed> <nloops>\n", argv[0]);
        exit(EXIT_FAILURE);
    }

    seed = atoi(argv[1]);
    nloops = atoi(argv[2]);

    for (j = 0; j < nloops; j++) {
        if (RAND_bytes(&buf, i) != 1)
            exit(1);
        printf("RAND_bytes: %u\n", (unsigned)buf);
```

```
    }
    return 0;
}
```

Check Information

Group: Algorithms library

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A3-1-1

It shall be possible to include any header file in multiple translation units without violating the One Definition Rule.

Description

Rule Definition

It shall be possible to include any header file in multiple translation units without violating the One Definition Rule.

Rationale

If a header file with variable or function definitions appears in multiple inclusion paths, the header file violates the One Definition Rule possibly leading to unpredictable behavior. For instance, a source file includes the header file `include.h` and another header file, which also includes `include.h`.

Polyspace Implementation

The rule checker flags variable and function definitions in header files.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Basic Concepts

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A3-1-3

Implementation files, that are defined locally in the project, should have a file name extension of ".cpp".

Description

Rule Definition

Implementation files, that are defined locally in the project, should have a file name extension of "*.cpp*".

Polyspace Implementation

Not case sensitive if you set the option `-dos`.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A3-1-4

When an array with external linkage is declared, its size shall be stated explicitly.

Description

Rule Definition

When an array is declared, its size shall either be stated explicitly or defined implicitly by initialization.

Rationale

Though you can declare an incomplete array type and later complete the type, specifying the array size during the first declaration makes the subsequent array access less error-prone.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Array Size Unspecified During Declaration

```
int array[10];
extern int array2[]; //Noncompliant
int array3[]= {0,1,2};
extern int array4[10];
```

In the declaration of `array2`, the array size is unspecified.

Check Information

Group: Basic Concepts

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A3-3-1

Objects or functions with external linkage (including members of named namespaces) shall be declared in a header file.

Description

Rule Definition

Objects or functions with external linkage shall be declared in a header file.

Rationale

If you declare a function or object in a header file, it is clear that the function or object is meant to be accessed in multiple translation units. If you intend to access the function or object from a single translation unit, declare it `static` or in an unnamed namespace.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Declaration in Header File Missing

This example uses two files:

- `decls.h`:

  ```
  extern int x;
  ```

- `file.cpp`:

  ```
  #include "decls.h"
  ```

```
int x = 0;
int y = 0; //Noncompliant
static int z = 0;
```

In this example, the variable `x` is declared in a header file but the variable `y` is not. The variable `z` is also not declared in a header file but it is declared with the `static` specifier and does not have external linkage.

Check Information

Group: Basic Concepts

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A3-9-1

Fixed width integer types from <cstdint>, indicating the size and signedness, shall be used in place of the basic numerical types.

Description

Rule Definition

Fixed width integer types from <cstdint>, indicating the size and signedness, shall be used in place of the basic numerical types.

Polyspace Implementation

Only allows use of basic types through direct `typedefs`.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A5-0-1

The value of an expression shall be the same under any order of evaluation that the standard permits.

Description

Rule Definition

The value of an expression shall be the same under any order of evaluation that the standard permits.

Rationale

If an expression results in different values depending on the order of evaluation, its value becomes implementation-defined.

Polyspace Implementation

An expression can have different values under the following conditions:

- The same variable is modified more than once in the expression, or is both read and written.
- The expression allows more than one order of evaluation.

Therefore, the rule checker forbids expressions where a variable is modified more than once and can cause different results under different orders of evaluation. The rule checker also detects cases where a volatile variable is read more than once in an expression.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Variable Modified More Than Once in Expression

```
int a[10], b[10];
#define COPY_ELEMENT(index) (a[(index)]=b[(index)])

void main () {
    int i=0, k=0;

    COPY_ELEMENT (k);         /* Compliant */
    COPY_ELEMENT (i++);       /* Non-compliant  */
}
```

In this example, the rule is violated by the statement `COPY_ELEMENT(i++)` because `i++` occurs twice and the order of evaluation of the two expressions is unspecified.

Variable Modified and Used in Multiple Function Arguments

```
void f (unsigned int param1, unsigned int param2) {}

void main () {
    unsigned int i=0;
    f ( i++, i );                 /* Non-compliant */
}
```

In this example, the rule is violated because it is unspecified whether the operation `i++` occurs before or after the second argument is passed to `f`. The call `f(i++,i)` can translate to either `f(0,0)` or `f(0,1)`.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A5-0-2

The condition of an if-statement and the condition of an iteration statement shall have type bool.

Description

Rule Definition

The condition of an if-statement and the condition of an iteration- statement shall have type bool.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A5-0-3

The declaration of objects shall contain no more than two levels of pointer indirection.

Description

Rule Definition

The declaration of objects shall contain no more than two levels of pointer indirection.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A5-0-4

Pointer arithmetic shall not be used with pointers to non-final classes.

Description

Rule Definition

Pointer arithmetic shall not be used with pointers to non-final classes.

Polyspace Implementation

Reports pointer arithmetic and array like access on expressions whose pointed type is used as a base class.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A5-1-1

Literal values shall not be used apart from type initialization, otherwise symbolic names shall be used instead.

Description

Rule Definition

Literal values shall not be used apart from type initialization, otherwise symbolic names shall be used instead.

Rationale

It is often unclear from use of literal constants what the constant represents. Using named constants improves the readability of the code.

Polyspace Implementation

The rule checker flags use of literal constants other than those with data type `char` in expressions, non-`const` initializations and `case` clauses of a `switch` statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A5-2-2

Traditional C-style casts shall not be used.

Description

Rule Definition

C-style casts (other than void casts) and functional notation casts (other than explicit constructor calls) shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A5-2-3

A cast shall not remove any const or volatile qualification from the type of a pointer or reference.

Description

Rule Definition

A cast shall not remove any const or volatile qualification from the type of a pointer or reference.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A5-2-4

reinterpret_cast shall not be used

Description

Rule Definition

reinterpret_cast shall not be used.

Rationale

`reinterpret_cast` is typically used to explicitly convert between two unrelated data types. For instance, in this example, `reinterpret_cast` converts the type `struct S*` to `int*`:

```
struct S { int x; } s;
int* ptr = reinterpret_cast<int*> (&s);
```

However, it is difficult to use `reinterpret_cast` and not violate type safety. If the result of `reinterpret_cast` is a pointer, it is safe to dereference the pointer only after you cast the pointer back to its original type.

Polyspace Implementation

The rule checker flags all uses of the `reinterpret_cast` keyword.

If the rule checker flags an use of `reinterpret_cast` that you consider safe, add a comment justifying the result. See “Address Polyspace Results Through Bug Fixes or Comments”.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of `reinterpret_cast` Keyword

```
class A {
    int x;
    int y;
    public:
      void getxy();
};

class B {
    int z;
    public:
      void getz();
};

void func (B* Bptr) {
    A* Aptr = reinterpret_cast<A*>(Bptr);
}
```

The use of `reinterpret_cast` violates this rule. The result of `reinterpret_cast` is not safe to dereference since `A` and `B` are unrelated classes. Dereferencing `Aptr` as if it were an `A*` pointer can result in illegal memory access.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A5-2-6

The operands of a logical && or \\ shall be parenthesized if the operands contain binary operators.

Description

Rule Definition

Each operand of a logical && or || shall be a postfix-expression.

Polyspace Implementation

During preprocessing, violations of this rule are detected on the expressions in `#if` directives.

The checker allows exceptions on associativity (a && b && c), (a || b || c).

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A5-3-3

Pointers to incomplete class types shall not be deleted.

Description

Rule Definition

Pointers to incomplete class types shall not be deleted.

Rationale

When you delete a pointer to an incomplete class, it is not possible to call any nontrivial destructor that the class might have. If the destructor performs cleanup activities such as memory deallocation, these activities do not happen.

A similar problem happens, for instance, when you downcast to a pointer to an incomplete class (downcasting is casting from a pointer to a base class to a pointer to a derived class). At the point of downcasting, the relationship between the base and derived class is not known. In particular, if the derived class inherits from multiple classes, at the point of downcasting, this information is not available. The downcasting cannot make the necessary adjustments for multiple inheritance and the resulting pointer cannot be dereferenced.

Polyspace Implementation

The check raises a defect when you delete or cast to a pointer to an incomplete class. An incomplete class is one whose definition is not visible at the point where the class is used.

For instance, the definition of class `Body` is not visible when the `delete` operator is called on a pointer to `Body`:

```
class Handle {
  class Body *impl;
public:
  ~Handle() { delete impl; }
```

```
  // ...
};
```

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Deletion of Pointer to Incomplete Class

```
class Handle {
  class Body *impl;
public:
  ~Handle() { delete impl; }
  // ...
};
```

In this example, the definition of class `Body` is not visible when the pointer to `Body` is deleted.

Correction — Define Class Before Deletion

One possible correction is to make sure that the class definition is visible when a pointer to the class is deleted.

```
class Handle {
  class Body *impl;
public:
  ~Handle();
  // ...
};

// Elsewhere
class Body { /* ... */ };

Handle::~Handle() {
  delete impl;
}
```

Correction — Use `std::shared_ptr`

Another possible correction is to use the `std::shared_ptr` type instead of a regular pointer.

```
#include <memory>

class Handle {
  std::shared_ptr<class Body> impl;
  public:
    Handle();
    ~Handle() {}
    // ...
};
```

Downcasting to Pointer to Incomplete Class

`File1.h`:

```
class Base {
protected:
  double var;
public:
  Base() : var(1.0) {}
  virtual void do_something();
  virtual ~Base();
};
```

`File2.h`:

```
void funcprint(class Derived *);
class Base *get_derived();
```

`File1.cpp`:

```
#include "File1.h"
#include "File2.h"

void getandprint() {
  Base *v = get_derived();
  funcprint(reinterpret_cast<class Derived *>(v));
}
```

`File2.cpp`:

```
#include "File2.h"
#include "File1.h"
#include <iostream>

class Base2 {
protected:
  short var2;
public:
  Base2() : var2(12) {}
};

class Derived : public Base2, public Base {
  float var_derived;
public:
    Derived() : Base2(), Base(), var_derived(1.2f) {}
    void do_something()
    {
        std::cout << "var_derived: "
                  << var_derived << ", var : " << var
                  << ", var2: " << var2 << std::endl;
    }
 };

void funcprint(Derived *d) {
  d->do_something();
}

Base *get_derived() {
  return new Derived;
}
```

In `File2.cpp`, class `Derived` derives from two classes, `Base` and `Base2`. This information about multiple inheritance is not available at the point of downcasting in `File1.cpp`. The result of downcasting is passed to the function `funcprint` and dereferenced in the body of `funcprint`. Because the downcasting was done with incomplete information, the dereference can be invalid.

Correction — Define Class Before Downcasting

One possible correction is to define the class `Derived` before downcasting a `Base*` pointer to a `Derived*` pointer.

In this corrected example, the downcasting is done in `File2.cpp` in the body of `funcprint` at a point where the definition of class `Derived` is visible. The downcasting is not done in `File1.cpp` where the definition of `Derived` is not visible. The changes from the previous incorrect example are highlighted.

`File1.h`:

```
class Base {
protected:
  double var;
public:
  Base() : var(1.0) {}
  virtual void do_something();
  virtual ~Base();
};
```

`File2.h`:

```
void funcprint(class Base *);
class Base *get_derived();
```

`File1.cpp`:

```
#include "File1.h"
#include "File2.h"

void getandprint() {
  Base *v = get_derived();
  funcprint(v);
}
```

`File2.cpp`:

```
#include "File2_corr.h"
#include "File1_corr.h"
#include <iostream>

class Base2 {
protected:
  short var2;
public:
  Base2() : var2(12) {}
};

class Derived : public Base2, public Base {
```

```
  float var_derived;

public:
    Derived() : Base2(), Base(), var_derived(1.2f) {}
    void do_something()
    {
        std::cout << "var_derived: "
                  << var_derived << ", var : " << var
                  << ", var2: " << var2 << std::endl;
    }
};

void funcprint(Base *d) {
  Derived *temp = dynamic_cast<Derived*>(d);
  if(temp)  {
     d->do_something();
  }
  else {
      //Handle error
  }
}

Base *get_derived() {
  return new Derived;
}
```

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A5-6-1

The right hand operand of the integer division or remainder operators shall not be equal to zero.

Description

Rule Definition

The right hand operand of the integer division or remainder operators shall not be equal to zero.

Rationale

- If the numerator is the minimum possible value and the denominator is `-1`, your division operation overflows because the result cannot be represented by the current variable size.
- If the denominator is zero, your division operation fails possibly causing your program to crash.

These risks can be used to execute arbitrary code. This code is usually outside the scope of a program's implicit security policy.

- If the second remainder operand is zero, your remainder operation fails, causing your program to crash.
- If the second remainder operand is `-1`, your remainder operation can overflow if the remainder operation is implemented based on the division operation that can overflow.
- If one of the operands is negative, the operation result is uncertain. For C89, the modulo operation is not standardized, so the result from negative operands is implementation-defined.

These risks can be exploited by attackers to gain access to your program or the target in general.

Polyspace Implementation

The checker raises a defect when:

- The denominator of a division or modulo operation can be a zero-valued integer.
- There are division operations where one or both of the integer operands is from an unsecure source.
- There are modulo operations with one or more tainted operands.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Dividing an Integer by Zero

```
int fraction(int num)
{
    int denom = 0;
    int result = 0;

    result = num/denom;

    return result;
}
```

A division by zero error occurs at `num/denom` because `denom` is zero.

Correction — Check Before Division

```
int fraction(int num)
{
    int denom = 0;
    int result = 0;

    if (denom != 0)
        result = num/denom;
```

```
    return result;
}
```

Before dividing, add a test to see if the denominator is zero, checking before division occurs. If `denom` is always zero, this correction can produce a dead code defect in your Polyspace results.

Correction — Change Denominator

One possible correction is to change the denominator value so that `denom` is not zero.

```
int fraction(int num)
{
    int denom = 2;
    int result = 0;

    result = num/denom;

    return result;
}
```

Modulo Operation with Zero

```
int mod_arr(int input)
{
    int arr[5];
    for(int i = 0; i < 5; i++)
    {
        arr[i] = input % i;
    }

    return arr[0]+arr[1]+arr[2]+arr[3]+arr[4];
}
```

In this example, Polyspace flags the modulo operation as a division by zero. Because modulo is inherently a division operation, the divisor (right hand argument) cannot be zero. The modulo operation uses the `for` loop index as the divisor. However, the `for` loop starts at zero, which cannot be an iterator.

Correction — Check Divisor Before Operation

One possible correction is checking the divisor before the modulo operation. In this example, see if the index `i` is zero before the modulo operation.

```
int mod_arr(int input)
{
    int arr[5];
    for(int i = 0; i < 5; i++)
    {
        if(i != 0)
        {
             arr[i] = input % i;
        }
        else
        {
             arr[i] = input;
        }
    }

    return arr[0]+arr[1]+arr[2]+arr[3]+arr[4];
}
```

Correction — Change Divisor

Another possible correction is changing the divisor to a nonzero integer. In this example, add one to the index before the `%` operation to avoid dividing by zero.

```
int mod_arr(int input)
{
    int arr[5];
    for(int i = 0; i < 5; i++)
    {
         arr[i] = input % (i+1);
    }

    return arr[0]+arr[1]+arr[2]+arr[3]+arr[4];
}
```

Division of Function Arguments

```
extern void print_int(int);

int taintedintdivision(int usernum, int userden) {
    int r =  usernum/userden;
    print_int(r);
    return r;
}
```

This example function divides two argument variables, then prints and returns the result. The argument values are unknown and can cause division by zero or integer overflow.

Correction — Check Values

One possible correction is to check the values of the numerator and denominator before performing the division.

```
#include "limits.h"

extern void print_int(int);

int taintedintdivision(int usernum, int userden) {
    int r = 0;
    if (userden!=0 && !(usernum=INT_MIN && userden==-1)) {
        r = usernum/userden;
    }
    print_int(r);
    return r;
}
```

Modulo with Function Arguments

```
extern void print_int(int);

int taintedintmod(int userden) {
    int rem =  128%userden;
    print_int(rem);
    return rem;
}
```

In this example, the function performs a modulo operation by using an input argument. The argument is not checked before calculating the remainder for values that can crash the program, such as 0 and -1.

Correction — Check Operand Values

One possible correction is to check the values of the operands before performing the modulo operation. In this corrected example, the modulo operation continues only if the second operand is greater than zero.

```
extern void print_int(int);
```

```
int taintedintmod(int userden) {
    int rem = 0;
    if (userden > 0) {
        rem = 128 % userden;
    }
    print_int(rem);
    return rem;
}
```

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A6-4-1

A switch statement shall have at least two case-clauses, distinct from the default label.

Description

Rule Definition

A switch statement shall have at least two case-clauses, distinct from the default label.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A6-5-2

A for loop shall contain a single loop-counter which shall not have floating-point type.

Description

Rule Definition

A for loop shall contain a single loop-counter which shall not have floating type.

Polyspace Implementation

The checker flags these situations:

- The `for` loop index has a floating point type.
- More than one loop counter is incremented in the `for` loop increment statement.

  For instance:

  ```
  for(i=0, j=0; i<10 && j < 10;i++, j++) {}
  ```
- A loop counter is not incremented in the `for` loop increment statement.

  For instance:

  ```
  for(i=0; i<10;) {}
  ```

  Even if you increment the loop counter in the loop body, the checker still raises a violation.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A6-5-4

For-init-statement and expression should not perform actions other than loop-counter initialization and modification.

Description

Rule Definition

For-init-statement and expression should not perform actions other than loop-counter initialization and modification.

Polyspace Implementation

- Reports if `loop` parameter cannot be determined. Assumes JSF® C++ Rule 200 is not violated. The `loop variable` parameter is assumed to be a variable.
- Assumes 1 loop parameter (see JSF C++ Rule 198), with non class type. JSF C++ Rule 200 must not be violated for this rule to be reported.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A6-6-1

The goto statement shall not be used.

Description

Rule Definition

The goto statement shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A7-1-4

The register keyword shall not be used.

Description

Rule Definition

The register keyword shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A7-1-6

The typedef specifier shall not be used

Description

Rule Definition

The typedef specifier shall not be used.

Rationale

The `using` syntax is a better alternative to `typedef`-s for defining aliases.

Since C++11, the `using` syntax allows you to define template aliases where the template arguments are not bound to a data type. For instance, the following statements define an alias `vectorType` for `vector`, where the argument `T` is not bound to a data type and can be substituted later:

```
template<class T, class Allocator = allocator<T>> class vector;
template<class T> using vectorType = vector<T, My_allocator<T>>;
vectorType<int> primes = {2,3,5,7,11,13,17,19,23,29};
```

The `typedef` keyword does not allow defining such template aliases.

Polyspace Implementation

The rule checker flags all uses of the `typedef` keyword.

If you do not want to remove certain instances of the `typedef` keyword, add a comment justifying those results. See “Address Polyspace Results Through Bug Fixes or Comments”.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of `typedef` Keyword

```
#include <cstdint>
#include <type_traits>

typedef std::int32_t (*fptr1) (std::int32_t); //Noncompliant
using fptr2 = std::int32_t (*) (std::int32_t); //Compliant

template <class T> using fptr3 = std::int32_t (*) (T); //Compliant
```

The alias definitions for `fptr1` and `fptr2` are exactly equivalent. There is no `typedef` equivalent for the alias definition for `fptr3`.

The use of `typedef`-s violates this rule. The rule requires that you stick to the `using` syntax for consistency even when a `typedef` equivalent exists.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A7-1-7

Each expression statement and identifier declaration shall be placed on a separate line.

Description

Rule Definition

Each expression statement and identifier declaration shall be placed on a separate line.

Polyspace Implementation

Reports when two consecutive expression statements are on the same line.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A7-1-9

A class, structure, or enumeration shall not be declared in the definition of its type.

Description

Rule Definition

A class, structure, or enumeration shall not be declared in the definition of its type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A7-2-4

In an enumeration, either (1) none, (2) the first or (3) all enumerators shall be initialized.

Description

Rule Definition

In an enumerator list, the = construct shall not be used to explicitly initialize members other than the first, unless all items are explicitly initialized.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declaration

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A7-3-1

All overloads of a function shall be visible from where it is called.

Description

Rule Definition

Multiple declarations for an identifier in the same namespace shall not straddle a using-declaration for that identifier.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declaration

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A7-5-1

A function shall not return a reference or a pointer to a parameter that is passed by reference to const.

Description

Rule Definition

A function shall not return a reference or a pointer to a parameter that is passed by reference or const reference.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declaration

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A7-5-2

Functions shall not call themselves, either directly or indirectly.

Description

Rule Definition

Functions should not call themselves, either directly or indirectly.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declaration

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A8-4-1

Functions shall not be defined using the ellipsis notation.

Description

Rule Definition

Functions shall not be defined using the ellipsis notation.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarators

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A8-4-2

All exit paths from a function with non-void return type shall have an explicit return statement with an expression.

Description

Rule Definition

All exit paths from a function with non- void return type shall have an explicit return statement with an expression.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarators

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A8-4-7

"in" parameters for "cheap to copy" types shall be passed by value.

Description

Rule Definition

"*in*" *parameters for* "*cheap to copy*" *types shall be passed by value.*

Polyspace Implementation

Report constant parameters references with `sizeof <= 2 * sizeof(int)`. Does not report for copy-constructor.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A8-5-0

All memory shall be initialized before it is read.

Description

Rule Definition

All variables shall have a defined value before they are used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarators

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A8-5-1

In an initialization list, the order of initialization shall be following: (1) virtual base classes in depth and left to right order of the inheritance graph, (2) direct base classes in left to right order of inheritance list, (3) non-static data members in the order they were declared in the class definition.

Description

Rule Definition

In an initialization list, the order of initialization shall be following: (1) virtual base classes in depth and left to right order of the inheritance graph, (2) direct base classes in left to right order of inheritance list, (3) non-static data members in the order they were declared in the class definition.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A8-5-2

Braced-initialization {}, without equals sign, shall be used for variable initialization.

Description

Rule Definition

Braced-initialization {}, without equals sign, shall be used for variable initialization.

Rationale

Braced initialization:

```
classType Object{arg1, arg2, ...};
```

is less ambiguous than other forms of initialization. Braced initialization has the following advantages:

- Prevents implicit narrowing conversions such as from `double` to `float`.
- Avoids the ambiguous syntax that leads to the problem of most vexing parse.

  For instance, from the declaration:

  ```
  ResourceType aResource();
  ```

  It is not immediately clear if `aResource` is a function returning a variable of type `ResourceType` or an object of type `ResourceType`.

  For more information, see `Ambiguous declaration syntax`.

The rule also forbids the use of = sign for initialization because the = sign can give the impression that an assignment or copy constructor is invoked even though it is not.

Polyspace Implementation

In general, the checker flags initializations of an object `obj1` of data type `Type` using these formats:

- `Type obj1 = obj2;`
- `Type obj1(obj2);`

Provided `obj1` and `obj2` have distinct data types.

The checker is enabled only if you specify a C++ version of C++11 or later. See `C++ standard version (-cpp-version)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Braced and Nonbraced Initialization

```
class ResourceType {
      int memberOne;
      int memberTwo;
    public:
      ResourceType() {memberOne = 0; memberTwo = 0;}
      ResourceType(int m, int n) {memberOne = m; memberTwo = n;}
      ResourceType(ResourceType &anotherResource) {
          memberOne = anotherResource.memberTwo;
          memberTwo = anotherResource.memberOne;
      }
};

void func() {
    ResourceType aResourceOne(); //Noncompliant
    ResourceType aResourceTwo(1, 2); //Noncompliant
    ResourceType aResourceThree = {1,2};   //Noncompliant

    ResourceType aResourceFour{1,2}; //Compliant

}
```

In this example, the function `func` declares four objects of type `ResourceType`. Only the declaration of `aResourceFour` does not violate this rule.

The declarations of `aResourceOne`, `aResourceTwo` and `aResourceThree` violate the rule. In particular:

- The declaration of `aResourceOne` suffers from the problem of most vexing parse. It is not clear whether `aResourceOne` is an object of type `ResourceType` or a function returning an object of type `ResourceType`.
- The declaration of `aResourceThree` seems to suggest that the copy constructor `ResourceType(ResourceType &)` is invoked for initialization. The copy constructor initializes the data member `memberOne` to 2 and `memberTwo` to 1. However, the constructor `ResourceType(int, int)` is invoked. This constructor initializes the data member `memberOne` to 1 and `memberTwo` to 2.

Check Information

Group: Declarators

See Also

`Ambiguous declaration syntax` | `Improper array initialization` | `Non-initialized variable` | `Variable shadowing` | `Write without a further read`

Introduced in R2019a

AUTOSAR C++14 Rule A9-3-1

Member functions shall not return non-const "raw" pointers or references to private or protected data owned by the class.

Description

Rule Definition

Member functions shall not return non-const handles to class-data.

Polyspace Implementation

The checker flags a rule violation only if a member function returns a non-`const` pointer or reference to a nonstatic data member. The rule does not apply to static data members.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Classes

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A9-5-1

Unions shall not be used.

Description

Rule Definition

Unions shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Classes

See Also

Introduced in R2019a

AUTOSAR C++14 Rule A9-6-1

Bit-fields shall be either unsigned integral, or enumeration (with underlying type of unsigned integral type).

Description

Rule Definition

Bit-fields shall be either unsigned integral, or enumeration (with underlying type of unsigned integral type).

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M0-1-1

A project shall not contain unreachable code.

Description

Rule Definition

A project shall not contain unreachable code.

Rationale

This rule flags situations where a group of statements is unreachable because of syntactic reasons. For instance, code following a `return` statement are always unreachable.

Unreachable code involve unnecessary maintenance and can often indicate programming errors.

Polyspace Implementation

Bug Finder and Code Prover check this coding rule differently. The analyses can produce different results.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Unreachable statements

```
int func(int arg) {
 int temp = 0;
```

```
 switch(arg) {
     temp = arg; // Noncompliant
     case 1:
     {
         break;
     }
     default:
     {
         break;
     }
 }
 return arg;
 arg++; // Noncompliant
}
```

These statements are unreachable:

- Statements inside a `switch` statement that do not belong to a `case` or `default` block.
- Statements after a `return` statement.

Check Information

Group: Language Independent Issues

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M0-1-10

Every defined function should be called at least once.

Description

Rule Definition

Every defined function shall be called at least once.

Rationale

If a function with a definition is not called, it might indicate a serious coding error. For instance, the function call is unreachable or a different function is called unintentionally.

Polyspace Implementation

The checker detects situations where a static function is defined but not called at all in its translation unit.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Uncalled Static Function

```
static void func1() {
}

static void func2() { //Noncompliant
}
```

```
void func3();

int main() {
    func1();
    return 0;
}
```

The `static` function `func2` is defined but not called.

The function `func3` is not called either, however, it is only declared and not defined. The absence of a call to `func3` does not violate the rule.

Check Information

Group: Language Independent Issues

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M0-1-2

A project shall not contain infeasible paths.

Description

Rule Definition

A project shall not contain infeasible paths.

Rationale

This rule flags situations where a group of statements is redundant because of nonsyntactic reasons. For instance, an `if` condition is always true or false. Code that is unreachable from syntactic reasons are flagged by rule 0-1-1.

Unreachable or redundant code involve unnecessary maintenance and can often indicate programming errors.

Polyspace Implementation

Bug Finder and Code Prover check this rule differently. The analysis can produce different results.

- Bug Finder uses the `Dead code` and `Useless if` checkers to detect violations of this rule.
- Code Prover does not use run-time checks to detect violations of this rule. Instead, Code Prover detects the violations at compile time.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Boolean Operations with Invariant Results

```
void func (unsigned int arg) {
 if (arg >= 0U) //Noncompliant
     arg  = 1U;
 if (arg < 0U) //Noncompliant
     arg = 1U;
}
```

An `unsigned int` variable is nonnegative. Both `if` conditions involving the variable are always true or always false and are therefore redundant.

Check Information

Group: Language Independent Issues

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M0-1-3

A project shall not contain unused variables.

Description

Rule Definition

A project shall not contain unused variables.

Polyspace Implementation

The checker flags local or global variables that are declared or defined but not used anywhere in the source files. This specification also applies to members of structures and classes.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of Named Bit Field for Padding

```
#include <iostream>
struct S {
    unsigned char b1 : 3;
    unsigned char pad: 1;  //Noncompliant
    unsigned char b2 : 4;
};
void init(struct S S_obj)
{
    S_obj.b1 = 0;
```

```
    S_obj.b2 = 0;
}
```

In this example, the bit field `pad` is used for padding the structure. Therefore, the field is never read or written and causes a violation of this rule. To avoid the violation, use an unnamed field for padding.

```
struct S {
    unsigned char b1 : 3;
    unsigned char : 1;
    unsigned char b2 : 4;
};
```

Check Information

Group: Language Independent Issues

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M0-1-9

There shall be no dead code.

Description

Rule Definition

There shall be no dead code.

Rationale

If an operation is reachable but removing the operation does not affect program behavior, the operation constitutes dead code. For instance, suppose that a variable is never read following a write operation. The write operation is redundant.

The presence of dead code can indicate an error in the program logic. Because a compiler can remove dead code, its presence can cause confusion for code reviewers.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Redundant Operations

```
#define ULIM 10000

int func(int arg) {
    int res;
    res = arg*arg + arg;
    if (res > ULIM)
        res = 0; //Noncompliant
```

```
    return arg;
}
```

In this example, the operations involving `res` are redundant because the function `func` returns its argument `arg`. All operations involving `res` can be removed without changing the effect of the function.

The checker flags the last write operation on `res` because the variable is never read after that point. The dead code can indicate an unintended coding error. For instance, you intended to return the value of `res` instead of `arg`.

Check Information

Group: Language Independent Issues

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M0-2-1

An object shall not be assigned to an overlapping object.

Description

Rule Definition

An object shall not be assigned to an overlapping object.

Rationale

When you assign an object to another object with overlapping memory, the behavior is undefined.

The exceptions are:

- You assign an object to another object with exactly overlapping memory and compatible type.
- You copy one object to another with `memmove`.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Assignment of Union Members

```
void func (void) {
    union {
        short i;
        int j;
    } a = {0}, b = {1};
```

```
    a.j = a.i;   //Noncompliant
    a = b;       //Compliant
}
```

In this example, the rule is violated when `a.i` is assigned to `a.j` because the two variables have overlapping regions of memory.

Check Information

Group: Language Independent Issues

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M10-1-1

Classes should not be derived from virtual bases.

Description

Rule Definition

Classes should not be derived from virtual bases.

Rationale

The use of virtual bases can lead to many confusing behaviors.

For instance, in an inheritance hierarchy involving a virtual base, the most derived class calls the constructor of the virtual base. Intermediate calls to the virtual base constructor are ignored.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of Virtual Bases

```
class Base {};
class Intermediate: public virtual Base {}; //Noncompliant
class Final: public Intermediate {};
```

In this example, the rule checker raises a violation when the `Intermediate` class is derived from the class `Base` with the `virtual` keyword.

The following behavior can be a potential source of confusion. When you create an object of type `Final`, the constructor of `Final` directly calls the constructor of `Base`. Any call to

the `Base` constructor from the `Intermediate` constructor are ignored. You might see unexpected results if you do not take into account this behavior.

Check Information

Group: Derived Classes

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M10-1-2

A base class shall only be declared virtual if it is used in a diamond hierarchy.

Description

Rule Definition

A base class shall only be declared virtual if it is used in a diamond hierarchy.

Rationale

This rule is less restrictive than `AUTOSAR C++14 Rule M10-1-1`. Rule M10-1-1 forbids the use of a virtual base anywhere in your code because a virtual base can lead to potentially confusing behavior.

Rule M10-1-2 allows the use of virtual bases in the one situation where they are useful, that is, as a common base class in diamond hierarchies.

For instance, the following diamond hierarchy violates rule M10-1-1 but not rule M10-1-2.

```
class Base {};
class Intermediate1: public virtual Base {};
class Intermediate2: public virtual Base {};
class Final: public Intermediate1, public Intermediate2 {};
```

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Derived Classes

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M10-1-3

An accessible base class shall not be both virtual and non-virtual in the same hierarchy.

Description

Rule Definition

An accessible base class shall not be both virtual and non-virtual in the same hierarchy.

Rationale

The checker flags situations where the same class is inherited as a virtual base class and a non-virtual base class in the same derived class. These situations defeat the purpose of virtual inheritance and causes multiple copies of the base class sub-object in the derived class object.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Base Class Both Virtual and Non-Virtual in Same Hierarchy

```
class Base {};
class Intermediate1: virtual public Base {};
class Intermediate2: virtual public Base {};
class Intermediate3: public Base {};
class Final: public Intermediate1, Intermediate2, Intermediate3 {}; //Noncompliant
```

In this example, the class `Base` is inherited in `Final` both as a virtual and non-virtual base class. The `Final` object contains at least two copies of a `Base` sub-object.

Check Information

Group: Derived Classes

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M10-2-1

All accessible entity names within a multiple inheritance hierarchy should be unique.

Description

Rule Definition

All accessible entity names within a multiple inheritance hierarchy should be unique.

Polyspace Implementation

The checker flags data members from different classes with conflicting names if the same class derives from these classes. For instance:

```
class B1
  {
    public:
      int count;
      void foo ( );
  };
class B2
  {
    public:
      int count;
      void foo ( );
  };

class D : public B1, public B2
  {
    public:
      void Bar ( )
      {
        ++B1::count;
        B1::foo ( );
      }
  };
```

If the data member access in the derived class is ambiguous, the analysis reports this issue as a compilation error and not a coding rule violation. For instance, a compilation error occurs in the preceding example if the class `D` is rewritten as:

```
class D : public B1, public B2
  {
    public:
      void Bar ( )
      {
        ++count;      // Is that B1::count or B2::count?
        foo ( );      // Is that B1::foo() or B2::foo()?
      }
  };
```

The checker does not check for conflicts between entities of different kinds, for instance, member functions against data members.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Derived Classes

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M10-3-3

A virtual function shall only be overridden by a pure virtual function if it is itself declared as pure virtual.

Description

Rule Definition

A virtual function shall only be overridden by a pure virtual function if it is itself declared as pure virtual.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Derived Classes

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M11-0-1

Member data in non-POD class types shall be private.

Description

Rule Definition

Member data in non- POD class types shall be private.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Member Access Control

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M12-1-1

An object's dynamic type shall not be used from the body of its constructor or destructor.

Description

Rule Definition

An object's dynamic type shall not be used from the body of its constructor or destructor.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Special Member Functions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M14-5-3

A copy assignment operator shall be declared when there is a template assignment operator with a parameter that is a generic parameter.

Description

Rule Definition

A copy assignment operator shall be declared when there is a template assignment operator with a parameter that is a generic parameter.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Templates

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M14-6-1

In a class template with a dependent base, any name that may be found in that dependent base shall be referred to using a qualified-id or this->.

Description

Rule Definition

In a class template with a dependent base, any name that may be found in that dependent base shall be referred to using a qualified-id or this->

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Templates

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M15-0-3

Control shall not be transferred into a try or catch block using a goto or a switch statement.

Description

Rule Definition

Control shall not be transferred into a try or catch block using a goto or a switch statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M15-1-2

NULL shall not be thrown explicitly.

Description

Rule Definition

NULL shall not be thrown explicitly.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M15-1-3

An empty throw (throw;) shall only be used in the compound statement of a catch handler.

Description

Rule Definition

An empty throw (throw;) shall only be used in the compound- statement of a catch handler.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M15-3-3

Handlers of a function-try-block implementation of a class constructor or destructor shall not reference non-static members from this class or its bases.

Description

Rule Definition

Handlers of a function-try-block implementation of a class constructor or destructor shall not reference non-static members from this class or its bases.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M15-3-6

Where multiple handlers are provided in a single try-catch statement or function-try-block for a derived class and some or all of its bases, the handlers shall be ordered most-derived to base class.

Description

Rule Definition

Where multiple handlers are provided in a single try-catch statement or function-try-block for a derived class and some or all of its bases, the handlers shall be ordered most-derived to base class.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M15-3-7

Where multiple handlers are provided in a single try-catch statement or function-try-block, any ellipsis (catch-all) handler shall occur last.

Description

Rule Definition

Where multiple handlers are provided in a single try-catch statement or function-try-block, any ellipsis (catch-all) handler shall occur last.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Exception Handling

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M16-0-1

#include directives in a file shall only be preceded by other pre-processor directives or comments.

Description

Rule Definition

#include directives in a file shall only be preceded by other preprocessor directives or comments.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M16-0-2

Macros shall only be #define'd or #undef'd in the global namespace.

Description

Rule Definition

Macros shall only be #define 'd or #undef 'd in the global namespace.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M16-0-5

Arguments to a function-like macro shall not contain tokens that look like pre-processing directives.

Description

Rule Definition

Arguments to a function-like macro shall not contain tokens that look like preprocessing directives.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M16-0-6

In the definition of a function-like macro, each instance of a parameter shall be enclosed in parentheses, unless it is used as the operand of # or ##.

Description

Rule Definition

In the definition of a function-like macro, each instance of a parameter shall be enclosed in parentheses, unless it is used as the operand of # or ##.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M16-0-7

Undefined macro identifiers shall not be used in #if or #elif pre-processor directives, except as operands to the defined operator.

Description

Rule Definition

Undefined macro identifiers shall not be used in #if or #elif preprocessor directives, except as operands to the defined operator.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M16-0-8

If the # token appears as the first token on a line, then it shall be immediately followed by a pre-processing token.

Description

Rule Definition

If the # token appears as the first token on a line, then it shall be immediately followed by a preprocessing token.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M16-1-1

The defined pre-processor operator shall only be used in one of the two standard forms.

Description

Rule Definition

The defined preprocessor operator shall only be used in one of the two standard forms.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M16-1-2

All #else, #elif and #endif pre-processor directives shall reside in the same file as the #if or #ifdef directive to which they are related.

Description

Rule Definition

All #else, #elif and #endif preprocessor directives shall reside in the same file as the #if or #ifdef directive to which they are related.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M16-2-3

Include guards shall be provided.

Description

Rule Definition

Include guards shall be provided.

Polyspace Implementation

The checker raises a violation if a header file does not contain an include guard.

For instance, this code uses an include guard for the `#define` and `#include` statements and does not violate the rule:

```
// Contents of a header file
#ifndef FILE_H

#define FILE_H
#include "libFile.h"

#endif
```

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M16-3-1

There shall be at most one occurrence of the # or ## operators in a single macro definition.

Description

Rule Definition

There shall be at most one occurrence of the # or ## operators in a single macro definition.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M16-3-2

The # and ## operators should not be used.

Description

Rule Definition

The # and ## operators should not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Preprocessing Directives

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M17-0-2

The names of standard library macros and objects shall not be reused.

Description

Rule Definition

The names of standard library macros and objects shall not be reused.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Library Introduction

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M17-0-3

The names of standard library functions shall not be overridden.

Description

Rule Definition

The names of standard library functions shall not be overridden.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Library Introduction

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M17-0-5

The setjmp macro and the longjmp function shall not be used.

Description

Rule Definition

The setjmp macro and the longjmp function shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Library Introduction

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M18-0-3

The library functions abort, exit, getenv and system from library <cstdlib> shall not be used.

Description

Rule Definition

The library functions abort, exit, getenv and system from library <cstdlib> shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Language Support Library

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M18-0-4

The time handling functions of library <ctime> shall not be used.

Description

Rule Definition

The time handling functions of library <ctime> shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Language Support Library

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M18-0-5

The unbounded functions of library <cstring> shall not be used.

Description

Rule Definition

The unbounded functions of library <cstring> shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Language Support Library

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M18-2-1

The macro offsetof shall not be used.

Description

Rule Definition

The macro offsetof shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Language Support Library

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M18-7-1

The signal handling facilities of <csignal> shall not be used.

Description

Rule Definition

The signal handling facilities of <csignal> shall not be used.

Rationale

Signal handling functions such as `signal` contains undefined and implementation-specific behavior.

You have to be very careful when using `signal` to avoid these behaviors.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Language Support Library

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M19-3-1

The error indicator errno shall not be used.

Description

Rule Definition

The error indicator errno shall not be used.

Rationale

Observing this rule encourages the good practice of not relying on `errno` to check error conditions.

Checking `errno` is not sufficient to guarantee absence of errors. Functions such as `fopen` might not set `errno` on error conditions. Often, you have to check the return value of such functions for error conditions.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of `errno`

```
#include <cstdlib>
#include <cerrno>

void func (const char* str) {
    errno = 0;  // Noncompliant
    int i = atoi(str);
    if(errno != 0) { // Noncompliant
```

```
        //Handle Error
    }
}
```

The use of `errno` violates this rule. The function `atoi` is not required to set `errno` if the input string cannot be converted to an integer. Checking `errno` later does not safeguard against possible failures in conversion.

Check Information

Group: Diagnostics Library

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M2-10-1

Different identifiers shall be typographically unambiguous.

Description

Rule Definition

Different identifiers shall be typographically unambiguous.

Rationale

When you use identifiers that are typographically close, you can confuse between them.

The identifiers should not differ by:

- The interchange of a lowercase letter with its uppercase equivalent.
- The presence or absence of the underscore character.
- The interchange of the letter `O` and the digit `0`.
- The interchange of the letter `I` and the digit `1`.
- The interchange of the letter `I` and the letter `l`.
- The interchange of the letter `S` and the digit `5`.
- The interchange of the letter `Z` and the digit `2`.
- The interchange of the letter `n` and the letter `h`.
- The interchange of the letter `B` and the digit `8`.
- The interchange of the letters `rn` and the letter `m`.

Polyspace Implementation

The rule checker does not consider the fully qualified names of variables when checking this rule.

Bug Finder and Code Prover check this coding rule differently. The analyses can produce different results.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Typographically Ambiguous Identifiers

```
void func(void) {
    int id1_numval;
    int id1_num_val;  /* Non-compliant */

    int id2_numval;
    int id2_numVal;   /* Non-compliant */

    int id3_lvalue;
    int id3_Ivalue;   /* Non-compliant */

    int id4_xyz;
    int id4_xy2;      /* Non-compliant */

    int id5_zer0;
    int id5_zer0;     /* Non-compliant */

    int id6_rn;
    int id6_m;        /* Non-compliant */
}
```

In this example, the rule is violated when identifiers that can be confused for each other are used.

Check Information

Group: Lexical Conventions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M2-13-2

Octal constants (other than zero) and octal escape sequences (other than "\0") shall not be used.

Description

Rule Definition

Octal constants (other than zero) and octal escape sequences (other than "\0") shall not be used.

Rationale

Octal constants are denoted by a leading zero. A developer or code reviewer can mistake an octal constant as a decimal constant with a redundant leading zero.

Octal escape sequences beginning with \ can also cause confusion. Inadvertently introducing an 8 or 9 in the digit sequence after \ breaks the escape sequence and introduces a new digit. A developer or code reviewer can ignore this issue and continue to treat the escape sequence as one digit.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of Octal Constants and Octal Escape Sequences

```
void func(void) {
  int busData[6];

  busData[0] = 100;
```

```
  busData[1] = 108;
  busData[2] = 052;      //Noncompliant
  busData[3] = 071;      //Noncompliant
  busData[4] = '\109';   //Noncompliant
  busData[5] = '\100';   //Noncompliant

}
```

The checker flags all octal constants (other than zero) and all octal escape sequences (other than `\0`).

In this example:

- The octal escape sequence contains the digit 9, which is not an octal digit. This escape sequence has implementation-defined behavior.
- The octal escape sequence `\100` represents the number 64, but the rule checker forbids this use.

Check Information

Group: Lexical Conventions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M2-13-3

A "U" suffix shall be applied to all octal or hexadecimal integer literals of unsigned type.

Description

Rule Definition

A "U" suffix shall be applied to all octal or hexadecimal integer literals of unsigned type.

Rationale

The signedness of a constant is determined from:

- Value of the constant.
- Base of the constant: octal, decimal or hexadecimal.
- Size of the various types.
- Any suffixes used.

Unless you use a suffix `u` or `U`, another developer looking at your code cannot determine easily whether a constant is signed or unsigned.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Lexical Conventions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M2-13-4

Literal suffixes shall be upper case.

Description

Rule Definition

Literal suffixes shall be upper case.

Rationale

Literal constants can end with the letter `l` (el). Enforcing literal suffixes to be upper case removes potential confusion between the letter `l` and the digit `1`.

For consistency, use upper case constants for other suffixes such as `U` (unsigned) and `F` (float).

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of Literal Constants with Lower Case Suffix

```
const int a = 0l; //Noncompliant
const int b = 0L; //Compliant
```

In this example, both `a` and `b` are assigned the same literal constant. However, from a quick glance, one can mistakenly assume that `a` is assigned the value `01` (octal one).

Check Information

Group: Lexical Conventions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M27-0-1

The stream input/output library <cstdio> shall not be used.

Description

Rule Definition

The stream input/output library <cstdio> shall not be used.

Rationale

Functions in `cstdio` such as `gets`, `fgetpos`, `fopen`, `ftell`, etc. have unspecified, undefined and implementation-defined behavior.

For instance:

- The `gets` function:

  ```
  char * gets ( char * buf );
  ```

  does not check if the number of characters provided at the standard input exceeds the buffer `buf`. The function can have unexpected behavior when the input exceeds the buffer.
- The `fopen` function has implementation-specific behavior related to whether it sets `errno` on errors or whether it accepts additional characters following the standard mode specifiers.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of `gets`

```
#include <cstdio>

void func() {
 char array[10];
 gets(array);
}
```

The use of `gets` violates this rule.

Check Information

Group: Input Output Library

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M2-7-1

The character sequence /* shall not be used within a C-style comment.

Description

Rule Definition

The character sequence / shall not be used within a C-style comment.*

Rationale

If your code contains a `/*` in a `/* */` comment, it typically means that you have inadvertently commented out code. See the example that follows.

Polyspace Implementation

You cannot justify a violation of this rule using source code annotations.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of /* in /* */ Comment

```
void foo() {
    /* Initializer functions
     setup();
    /* Step functions */
}
```

In this example, the call to `setup()` is commented out because the ending `*/` is omitted, perhaps inadvertently. The checker flags this issue by highlighting the `/*` in the `/*  */` comment.

Check Information

Group: Lexical Conventions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M3-1-2

Functions shall not be declared at block scope.

Description

Rule Definition

Functions shall not be declared at block scope.

Rationale

It is a good practice to place all declarations at the namespace level.

Additionally, if you declare a function at block scope, it is often not clear if the statement is a function declaration or an object declaration with a call to the constructor.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Function Declarations at Block Scope

```
class A {
};

void b1() {
    void func(); //Noncompliant
    A a();   //Noncompliant
}
```

In this example, the declarations of `func` and `a` are in the block scope of `b1`.

The second function declaration can cause confusion because it is not clear if `a` is a function that returns an object of type `A` or `a` is itself an object of type `A`.

Check Information

Group: Basic Concepts

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M3-2-1

All declarations of an object or function shall have compatible types.

Description

Rule Definition

All declarations of an object or function shall have compatible types.

Rationale

If the declarations of an object or function in two different translation units have incompatible types, the behavior is undefined.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Basic Concepts

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M3-2-2

The One Definition Rule shall not be violated.

Description

Rule Definition

The One Definition Rule shall not be violated.

Rationale

Violations of the One Definition Rule leads to undefined behavior.

Polyspace Implementation

The checker flags situations where the same function or object has multiple definitions and the definitions differ by some token.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Different Tokens in Same Type Definition

This example uses two files:

- `file1.cpp`:

  ```
  struct S
  {
  ```

```
   int x;
   int y;
};
```

- `file2.cpp`:

```
struct S
{
   int y;
   int x;
};
```

In this example, both `file1.cpp` and `file2.cpp` define the structure `S`. However, the definitions switch the order of the structure fields.

Check Information

Group: Basic Concepts

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M3-2-3

A type, object or function that is used in multiple translation units shall be declared in one and only one file.

Description

Rule Definition

A type, object or function that is used in multiple translation units shall be declared in one and only one file.

Rationale

If you declare an identifier in a header file, you can include the header file in any translation unit where the identifier is defined or used. In this way, you ensure consistency between:

- The declaration and the definition.
- The declarations in different translation units.

The rule enforces the practice of declaring external objects or functions in header files.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Basic Concepts

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M3-2-4

An identifier with external linkage shall have exactly one definition.

Description

Rule Definition

An identifier with external linkage shall have exactly one definition.

Rationale

If an identifier has multiple definitions or no definitions, it can lead to undefined behavior.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Multiple Definitions of Identifier

This example uses two files:

- `file1.cpp`:

  ```
  int x = 0;
  ```

- `file2.cpp`:

  ```
  int x = 1;
  ```

The same identifier `x` is defined in both files.

Check Information

Group: Basic Concepts

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M3-3-2

If a function has internal linkage then all re-declarations shall include the static storage class specifier.

Description

Rule Definition

If a function has internal linkage then all re-declarations shall include the static storage class specifier.

Rationale

If a function declaration has the `static` storage class specifier, it has internal linkage. Subsequent redeclarations of the function have internal linkage even without the `static` specifier.

However, if you do not specify the `static` keyword explicitly, it is not immediately clear from a declaration whether the function has internal linkage.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Missing `static` Specifier from Redeclaration

```
static void func1 ();
static void func2 ();

void func1() {}  //Noncompliant
static void func2() {}
```

In this example, the function `func1` is declared `static` but defined without the `static` specifier.

Check Information

Group: Basic Concepts

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M3-4-1

An identifier declared to be an object or type shall be defined in a block that minimizes its visibility.

Description

Rule Definition

An identifier declared to be an object or type shall be defined in a block that minimizes its visibility.

Rationale

Defining variables with the minimum possible block scope reduces the possibility that they might later be accessed unintentionally.

For instance, if an object is meant to be accessed in one function only, declare the object local to the function.

Polyspace Implementation

The rule checker determines if an object is used in one block only. If the object is used in one block but defined outside the block, the checker raises a violation.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Use of Global Variable in Single Function

```
static int countReset; //Noncompliant

volatile int check;

void increaseCount() {
    int count = countReset;
    while(check%2) {
     count++;
    }
}
```

In this example, the variable `countReset` is declared global used in one function only. A compliant solution declares the variable local to the function to reduce its visibility.

Check Information

Group: Basic Concepts

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M3-9-1

The types used for an object, a function return type, or a function parameter shall be token-for-token identical in all declarations and re-declarations.

Description

Rule Definition

The types used for an object, a function return type, or a function parameter shall be token-for-token identical in all declarations and re-declarations.

Rationale

If a redeclaration is not token-for-token identical to the previous declaration, it is not clear from visual inspection which object or function is being redeclared.

Polyspace Implementation

The rule checker compares the current declaration with the last seen declaration.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Identical Declarations That Do Not Match Token for Token

```
typedef int* intptr;

int* map;
extern intptr map; //Noncompliant
```

```
intptr table;
extern intptr table; //Compliant
```

In this example, the variable `map` is declared twice. The second declaration uses a `typedef` which resolves to the type of the first declaration. Because of the `typedef`, the second declaration is not token-for-token identical to the first.

Check Information

Group: Basic Concepts

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M3-9-3

The underlying bit representations of floating-point values shall not be used.

Description

Rule Definition

The underlying bit representations of floating-point values shall not be used.

Rationale

The underlying bit representations of floating point values vary across compilers. If you directly use the underlying representation of floating point values, your program is not portable across implementations.

Polyspace Implementation

The rule checker flags conversions from pointers to floating point types into pointers to integer types, and vice versa.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Using Underlying Representation of Floating-Point Values

```
float fabs2(float f) {
    unsigned int* ptr = reinterpret_cast <unsigned int*> (&f); //Noncompliant
    *(ptr + 3) &= 0x7f;
```

```
    return f;
}
```

In this example, the `reinterpret_cast` attempts to cast a floating-point value to an integer and access the underlying bit representation of the floating point value.

Check Information

Group: Basic Concepts

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M4-10-1

NULL shall not be used as an integer value.

Description

Rule Definition

NULL shall not be used as an integer value.

Rationale

In C++, you can use the literals 0 and NULL as both an integer and a null pointer constant. However, use of 0 as a null pointer constant or NULL as an integer can cause developer confusion.

This rule restricts the use of NULL to null pointer constants. `AUTOSAR C++14 Rule M4-10-2` restricts the use of the literal 0 to integers.

Polyspace Implementation

The checker flags assignment of NULL to an integer variable or binary operations involving NULL and an integer. Assignments can be direct or indirect such as passing NULL as integer argument to a function.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Compliant and Noncompliant Uses of NULL

```
#include <cstddef>

void checkInteger(int);
void checkPointer(int *);

void main() {
    checkInteger(NULL); //Noncompliant
    checkPointer(NULL); //Compliant
}
```

In this example, the use of `NULL` as argument to the `checkInteger` function is noncompliant because the function expects an `int` argument.

Check Information

Group: Standard Conversions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M4-10-2

Literal zero (0) shall not be used as the null-pointer-constant.

Description

Rule Definition

Literal zero (0) shall not be used as the null-pointer-constant.

Rationale

In C++, you can use the literals 0 and NULL as both an integer and a null pointer constant. However, use of 0 as a null pointer constant or NULL as an integer can cause developer confusion.

This rule restricts the use of the literal 0 to integers. `AUTOSAR C++14 Rule M4-10-1` restricts the use of NULL to null pointer constants.

Polyspace Implementation

The checker flags assignment of 0 to a pointer variable or binary operations involving 0 and a pointer. Assignments can be direct or indirect such as passing 0 as pointer argument to a function.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Compliant and Noncompliant Uses of Literal 0

```
#include <cstddef>

void checkInteger(int);
void checkPointer(int *);

void main() {
    checkInteger(0); //Compliant
    checkPointer(0); //Noncompliant
}
```

In this example, the use of 0 as argument to the `checkPointer` function is noncompliant because the function expects an `int *` argument.

Check Information

Group: Standard Conversions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M4-5-1

Expressions with type bool shall not be used as operands to built-in operators other than the assignment operator =, the logical operators &&, ||, !, the equality operators == and ! =, the unary & operator, and the conditional operator.

Description

Rule Definition

Expressions with type bool shall not be used as operands to built-in operators other than the assignment operator =, the logical operators &&, ||, !, the equality operators == and !=, the unary & operator, and the conditional operator.

Rationale

Operators other than the ones mentioned in the rule do not produce meaningful results with `bool` operands. Use of `bool` operands with these operators can indicate programming errors. For instance, you intended to use the logical operator `||` but used the bitwise operator `|` instead.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Compliant and Noncompliant Uses of `bool` Operands

```
void boolOperations() {
    bool lhs = true;
    bool rhs = false;
```

```
    int res;

    if(lhs & rhs) {} //Noncompliant
    if(lhs < rhs) {} //Noncompliant
    if(~rhs) {}      //Noncompliant
    if(lhs ^ rhs) {} //Noncompliant
    if(lhs == rhs) {} //Compliant
    if(!rhs) {}       //Compliant
    res = lhs? -1:1;  //Compliant
}
```

In this example, `bool` operands do not violate the rule when used with the `==`, `!` and the `?` operators.

Check Information

Group: Standard Conversions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M4-5-3

Expressions with type (plain) char and wchar_t shall not be used as operands to built-in operators other than the assignment operator =, the equality operators == and ! =, and the unary & operator.

Description

Rule Definition

Expressions with type (plain) char and wchar_t shall not be used as operands to built-in operators other than the assignment operator =, the equality operators == and !=, and the unary & operator. N

Rationale

The C++03 Standard only requires that the characters `'0'` to `'9'` have consecutive values. Other characters do not have well-defined values. If you use these characters in operations other than the ones mentioned in the rule, you implicitly use their underlying values and might see unexpected results.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Compliant and Noncompliant Uses of Character Operands

```
void charManipulations (char ch) {

    char initChar = 'a'; //Compliant
    char finalChar = 'z'; //Compliant
```

```
    if(ch == initChar) {} //Compliant
    if( (ch >= initChar) && (ch <= finalChar)) {} //Noncompliant
    else if( (ch >= '0') && (ch <= '9') ) {} //Compliant by exception
}
```

In this example, character operands do not violate the rule when used with the = and == operators. Character operands can also be used with relational operators as long as the comparison is performed with the digits `'0'` to `'9'`.

Check Information

Group: Standard Conversions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-0-10

If the bitwise operators ~and << are applied to an operand with an underlying type of unsigned char or unsigned short, the result shall be immediately cast to the underlying type of the operand.

Description

Rule Definition

If the bitwise operators ~ and << are applied to an operand with an underlying type of unsigned char or unsigned short, the result shall be immediately cast to the underlying type of the operand.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-0-11

The plain char type shall only be used for the storage and use of character values.

Description

Rule Definition

The plain char type shall only be used for the storage and use of character values.

Polyspace Implementation

The checker raises a violation when a value of signed or unsigned integer type is implicitly converted to the plain char type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-0-12

Signed char and unsigned char type shall only be used for the storage and use of numeric values.

Description

Rule Definition

Signed char and unsigned char type shall only be used for the storage and use of numeric values.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-0-14

The first operand of a conditional-operator shall have type bool.

Description

Rule Definition

The first operand of a conditional-operator shall have type bool.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-0-15

Array indexing shall be the only form of pointer arithmetic.

Description

Rule Definition

Array indexing shall be the only form of pointer arithmetic.

Polyspace Implementation

The checker flags:

- Arithmetic operations on all pointers, for instance `p+I`, `I+p` and `p-I`, where `p` is a pointer and `I` an integer..
- Array indexing on nonarray pointers.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-0-17

Subtraction between pointers shall only be applied to pointers that address elements of the same array.

Description

Rule Definition

Subtraction between pointers shall only be applied to pointers that address elements of the same array.

Polyspace Implementation

Use Bug Finder for this checker. The rule checker performs the same checks as `Subtraction or comparison between pointers to different arrays`. Code Prover can fail to detect some violations.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-0-18

>, >=, <, <= shall not be applied to objects of pointer type, except where they point to the same array.

Description

Rule Definition

>, >=, <, <= shall not be applied to objects of pointer type, except where they point to the same array.

Polyspace Implementation

Use Bug Finder for this checker. The rule checker performs the same checks as `Subtraction or comparison between pointers to different arrays`. Code Prover can fail to detect some violations.

The checker ignores casts when showing the violation on relational operator use with pointers types.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-0-2

Limited dependence should be placed on C++ operator precedence rules in expressions.

Description

Rule Definition

Limited dependence should be placed on C++ operator precedence rules in expressions.

Rationale

Use parentheses to clearly indicate the order of evaluation.

Depending on operator precedence can cause the following issues:

- If you or another code reviewer reviews the code, the intended order of evaluation is not immediately clear.
- It is possible that the result of the evaluation does not meet your expectations. For instance:
  - In the operation `*p++`, it is possible that you expect the dereferenced value to be incremented. However, the pointer `p` is incremented before the dereference.
  - In the operation `(x == y | z)`, it is possible that you expect `x` to be compared with `y | z`. However, the `==` operation happens before the `|` operation.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Evaluation Order Dependent on Operator Precedence Rules

```
#include <cstdio>

void showbits(unsigned int x) {
    for(int i = (sizeof(int) * 8) - 1; i >= 0; i--) {
       (x & 1u << i) ? putchar('1') : putchar('0'); // Noncompliant
    }
    printf("\n");
}
```

In this example, the checker flags the operation `x & 1u << i` because the statement relies on operator precedence rules for the `<<` operation to happen before the `&` operation. If this is the intended order, the operation can be rewritten as `x & (1u << i)`.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-0-20

Non-constant operands to a binary bitwise operator shall have the same underlying type.

Description

Rule Definition

Non-constant operands to a binary bitwise operator shall have the same underlying type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-0-21

Bitwise operators shall only be applied to operands of unsigned underlying type.

Description

Rule Definition

Bitwise operators shall only be applied to operands of unsigned underlying type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-0-3

A cvalue expression shall not be implicitly converted to a different underlying type.

Description

Rule Definition

A cvalue expression shall not be implicitly converted to a different underlying type.

Rationale

This rule ensures that the result of the expression does not overflow when converted to a different type.

Polyspace Implementation

Expressions flagged by this checker follow the detailed specifications for cvalue expressions from the MISRA C++ documentation.

The underlying data type of a cvalue expression is the widest of operand data types in the expression. For instance, if you add two variables, one of type `int8_t` (`typedef` for `char`) and another of type `int32_t` (`typedef` for `int`), the addition has underlying type `int32_t`. If you assign the sum to a variable of type `int8_t`, the rule is violated.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Implicit Conversion of Cvalue Expression

```
typedef char int8_t;
typedef signed int int32_t;

void func ( )
  {
    int32_t s32;
    int8_t s8;
    s32 = s8 + s8; //Noncompliant
    s32 = s32 + s8; //Compliant
  }
```

In this example, the rule is violated when two variables of type `int8_t` are added and the result is assigned to a variable of type `int32_t`. The underlying type of the addition does not take into account the integer promotion involved and is simply the widest of operand data types, in this case, `int8_t`.

The rule is not violated if one of the operands has type `int32_t` and the result is assigned to a variable of type `int32_t`. In this case, the underlying data type of the addition is the same as the type of the variable to which the result is assigned.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-0-4

An implicit integral conversion shall not change the signedness of the underlying type.

Description

Rule Definition

An implicit integral conversion shall not change the signedness of the underlying type.

Rationale

Some conversions from signed to unsigned data types can lead to implementation-defined behavior. You can see unexpected results from the conversion.

Polyspace Implementation

The checker flags implicit conversions from a signed to an unsigned integer data type or vice versa.

The checker assumes that `ptrdiff_t` is a signed integer.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Implicit Conversions that Change Signedness

```
typedef char int8_t;
typedef unsigned char uint8_t;
```

```
void func()
  {
    int8_t s8;
    uint8_t u8;

    s8 = u8; //Noncompliant
    u8 = s8 + u8; //Noncompliant
    u8 = static_cast< uint8_t > ( s8 ) + u8; //Compliant
}
```

In this example, the rule is violated when a variable with a variable with signed data type is implicitly converted to a variable with unsigned data type or vice versa. If the conversion is explicit, as in the preceding example, the rule violation does not occur.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-0-5

There shall be no implicit floating-integral conversions.

Description

Rule Definition

There shall be no implicit floating-integral conversions.

Polyspace Implementation

This rule takes precedence over 5-0-4 and 5-0-6 if they apply at the same time.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-0-6

An implicit integral or floating-point conversion shall not reduce the size of the underlying type.

Description

Rule Definition

An implicit integral or floating-point conversion shall not reduce the size of the underlying type.

Rationale

A conversion that reduces the size of the underlying type can result in loss of information.

Polyspace Implementation

If the conversion is to a narrower integer with a different sign, then rule M5-0-4 takes precedence over rule M5-0-6. Only rule M5-0-4 is shown.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-0-7

There shall be no explicit floating-integral conversions of a cvalue expression.

Description

Rule Definition

There shall be no explicit floating-integral conversions of a cvalue expression.

Rationale

If you evaluate an expression and later cast the result to a different type, the cast has no effect on the underlying type of the evaluation. For instance, in this example, the result of an integer division is then cast to a floating-point type.

```
short num;
short den;
float res;
res= static_cast<float> (num/den);
```

However, a developer or code reviewer can expect that the evaluation uses the data type to which the result is cast later. For instance, one can expect a floating-point division because of the later cast.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Conversion of Division Result from Integer to Floating Point

```
void func() {
     short num;
```

```
    short den;
    short res_short;
    float res_float;

    res_float = static_cast<float> (num/den); //Noncompliant

    res_short = num/den;
    res_short = static_cast<float> (res_float); //Compliant

}
```

In this example, the first cast on the division result violates the rule but the second cast does not.

- The first cast can lead to the incorrect expectation that the expression is evaluated with an underlying type `float`.
- The second cast makes it clear that the expression is evaluated with the underlying type `short`. The result is then cast to the type `float`.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-0-8

An explicit integral or floating-point conversion shall not increase the size of the underlying type of a cvalue expression.

Description

Rule Definition

An explicit integral or floating-point conversion shall not increase the size of the underlying type of a cvalue expression.

Rationale

If you evaluate an expression and later cast the result to a different type, the cast has no effect on the underlying type of the evaluation. For instance, in this example, the sum of two `short` operands is cast to the wider type `int`.

```
short op1;
short op2;
int res;
res= static_cast<int> (op1 + op2);
```

However, a developer or code reviewer can expect that the evaluation uses the data type to which the result is cast later. For instance, one can expect a sum with the underlying type `int` because of the later cast.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Conversion of Sum to Wider Integer Type

```
void func() {
     short op1;
     short op2;
     int res;

     res = static_cast<int> (op1 + op2); //Noncompliant
     res = static_cast<int> (op1) + op2; //Compliant

}
```

In this example, the first cast on the sum violates the rule but the second cast does not.

- The first cast can lead to the incorrect expectation that the sum is evaluated with an underlying type `int`.
- The second cast first converts one of the operands to `int` so that the sum is actually evaluated with the underlying type `int`.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-0-9

An explicit integral conversion shall not change the signedness of the underlying type of a cvalue expression.

Description

Rule Definition

An explicit integral conversion shall not change the signedness of the underlying type of a cvalue expression.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-14-1

The right hand operand of a logical &&, || operators shall not contain side effects.

Description

Rule Definition

The right hand operand of a logical && or || operator shall not contain side effects.

Polyspace Implementation

The checker does not show a warning on volatile accesses and function calls.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-18-1

The comma operator shall not be used.

Description

Rule Definition

The comma operator shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-19-1

Evaluation of constant unsigned integer expressions shall not lead to wrap-around.

Description

Rule Definition

Evaluation of constant unsigned integer expressions should not lead to wrap-around.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-2-10

The increment (++) and decrement (âˆ’â€™âˆ’) operators shall not be mixed with other operators in an expression.

Description

Rule Definition

The increment (++) and decrement (--) operators should not be mixed with other operators in an expression.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-2-11

The comma operator, && operator and the || operator shall not be overloaded.

Description

Rule Definition

The comma operator, && operator and the || operator shall not be overloaded.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-2-12

An identifier with array type passed as a function argument shall not decay to a pointer.

Description

Rule Definition

An identifier with array type passed as a function argument shall not decay to a pointer.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-2-2

A pointer to a virtual base class shall only be cast to a pointer to a derived class by means of dynamic_cast.

Description

Rule Definition

A pointer to a virtual base class shall only be cast to a pointer to a derived class by means of dynamic_cast.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-2-3

Casts from a base class to a derived class should not be performed on polymorphic types.

Description

Rule Definition

Casts from a base class to a derived class should not be performed on polymorphic types.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-2-6

A cast shall not convert a pointer to a function to any other pointer type, including a pointer to function type.

Description

Rule Definition

A cast shall not convert a pointer to a function to any other pointer type, including a pointer to function type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-2-8

An object with integer type or pointer to void type shall not be converted to an object with pointer type.

Description

Rule Definition

An object with integer type or pointer to void type shall not be converted to an object with pointer type.

Polyspace Implementation

The checker allows an exception on zero constants.

Objects with pointer type include objects with pointer-to-function type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-2-9

A cast shall not convert a pointer type to an integral type.

Description

Rule Definition

A cast should not convert a pointer type to an integral type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-3-1

Each operand of the ! operator, the logical && or the logical || operators shall have type bool.

Description

Rule Definition

Each operand of the ! operator, the logical && or the logical || operators shall have type bool.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-3-2

The unary minus operator shall not be applied to an expression whose underlying type is unsigned.

Description

Rule Definition

The unary minus operator shall not be applied to an expression whose underlying type is unsigned.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-3-3

The unary & operator shall not be overloaded.

Description

Rule Definition

The unary & operator shall not be overloaded.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-3-4

Evaluation of the operand to the sizeof operator shall not contain side effects.

Description

Rule Definition

Evaluation of the operand to the sizeof operator shall not contain side effects.

Polyspace Implementation

The checker does not show a warning on volatile accesses and function calls

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M5-8-1

The right hand operand of a shift operator shall lie between zero and one less than the width in bits of the underlying type of the left hand operand.

Description

Rule Definition

The right hand operand of a shift operator shall lie between zero and one less than the width in bits of the underlying type of the left hand operand.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Expressions

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-2-1

Assignment operators shall not be used in sub-expressions.

Description

Rule Definition

Assignment operators shall not be used in sub-expressions.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-2-2

Floating-point expressions shall not be directly or indirectly tested for equality or inequality.

Description

Rule Definition

Floating-point expressions shall not be directly or indirectly tested for equality or inequality.

Polyspace Implementation

The checker detects the use of == or != with floating-point variables or expressions. The checker does not detect indirectly testing of equality, for instance, using the <= operator.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-2-3

Before preprocessing, a null statement shall only occur on a line by itself; it may be followed by a comment, provided that the first character following the null statement is a white-space character.

Description

Rule Definition

Before preprocessing, a null statement shall only occur on a line by itself; it may be followed by a comment, provided that the first character following the null statement is a white - space character.

Polyspace Implementation

The checker considers a null statement as a line where the first character excluding comments is a semicolon. The checker flags situations where:

- Comments appear before the semicolon.

  For instance:

  ```
  /* wait for pin */ ;
  ```

- Comments appear immediately after the semicolon without a white space in between.

  For instance:

  ```
  ;// wait for pin
  ```

The checker also shows a violation when a second statement appears on the same line following the null statement.

For instance:

```
; count++;
```

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-3-1

The statement forming the body of a switch, while, do ... while or for statement shall be a compound statement.

Description

Rule Definition

The statement forming the body of a switch, while, do ... while or for statement shall be a compound statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-4-1

An if (condition) construct shall be followed by a compound statement. The else keyword shall be followed by either a compound statement, or another if statement.

Description

Rule Definition

An if (condition) construct shall be followed by a compound statement. The else keyword shall be followed by either a compound statement, or another if statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-4-2

All if ... else if constructs shall be terminated with an else clause.

Description

Rule Definition

All if ... else if constructs shall be terminated with an else clause.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-4-3

A switch statement shall be a well-formed switch statement.

Description

Rule Definition

A switch statement shall be a well-formed switch statement.

Polyspace Implementation

The checker flags these situations:

- A statement occurs between the `switch` statement and the first `case` statement.

  For instance:

  ```
  switch(ch) {
    int temp;
    case 1:
      break;
    default:
      break;
  }
  ```
- A label or a jump statement such as `goto` or `return` occurs in the `switch` block.
- A variable is declared in a `case` statement (outside any block).

  For instance:

  ```
  switch(ch) {
    case 1:
      int temp;
      break;
    default:
      break;
  }
  ```

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-4-4

A switch-label shall only be used when the most closely-enclosing compound statement is the body of a switch statement.

Description

Rule Definition

A switch-label shall only be used when the most closely-enclosing compound statement is the body of a switch statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-4-5

An unconditional throw or break statement shall terminate every non-empty switch-clause.

Description

Rule Definition

An unconditional throw or break statement shall terminate every non - empty switch-clause.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-4-6

The final clause of a switch statement shall be the default-clause.

Description

Rule Definition

The final clause of a switch statement shall be the default-clause.

Polyspace Implementation

The checker detects `switch` statements that do not have a final `default` clause.

The checker does not raise a violation if the `switch` variable is an `enum` with finite number of values and you have a `case` clause for each value. For instance:

```
enum Colours { RED, BLUE, GREEN } colour;

switch ( colour ) {
      case RED:
        break;
      case BLUE:
        break;
      case GREEN:
        break;
}
```

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-4-7

The condition of a switch statement shall not have bool type.

Description

Rule Definition

The condition of a switch statement shall not have bool type.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-5-2

If loop-counter is not modified by âˆ’â€™â€™ or ++, then, within condition, the loop-counter shall only be used as an operand to <=, <, > or >=.

Description

Rule Definition

If loop-counter is not modified by -- or ++, then, within condition, the loop-counter shall only be used as an operand to <=, <, > or >=.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-5-3

The loop-counter shall not be modified within condition or statement.

Description

Rule Definition

The loop-counter shall not be modified within condition or statement.

Rationale

The `for` loop has a specific syntax for modifying the loop counter. A code reviewer expects modification using that syntax. Modifying the loop counter elsewhere can make the code harder to review.

Polyspace Implementation

The checker flags modification of a `for` loop counter in the loop body or the loop condition (the condition that is checked to see if the loop must be terminated).

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-5-4

The loop-counter shall be modified by one of: âˆ’â€™â€™, ++, â€™ = n, or + = n; where n remains constant for the duration of the loop.

Description

Rule Definition

The loop-counter shall be modified by one of: --, ++, -=n, or +=n ; where n remains constant for the duration of the loop.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-5-5

A loop-control-variable other than the loop-counter shall not be modified within condition or expression.

Description

Rule Definition

A loop-control-variable other than the loop-counter shall not be modified within condition or expression.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-5-6

A loop-control-variable other than the loop-counter which is modified in statement shall have type bool.

Description

Rule Definition

A loop-control-variable other than the loop-counter which is modified in statement shall have type bool.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-6-1

Any label referenced by a goto statement shall be declared in the same block, or in a block enclosing the goto statement.

Description

Rule Definition

Any label referenced by a goto statement shall be declared in the same block, or in a block enclosing the goto statement.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-6-2

The goto statement shall jump to a label declared later in the same function body.

Description

Rule Definition

The goto statement shall jump to a label declared later in the same function body.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M6-6-3

The continue statement shall only be used within a well-formed for loop.

Description

Rule Definition

The continue statement shall only be used within a well-formed for loop.

Polyspace Implementation

The checker flags the use of `continue` statements in:

- `for` loops that are not well-formed, that is, loops that violate rules 6-5-x.
- `while` loops.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Statements

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M7-1-2

A pointer or reference parameter in a function shall be declared as pointer to const or reference to const if the corresponding object is not modified.

Description

Rule Definition

A pointer or reference parameter in a function shall be declared as pointer to const or reference to const if the corresponding object is not modified.

Polyspace Implementation

The checker flags pointers where the underlying object is not const-qualified but never modified in the function body.

If a variable is passed to another function by reference or pointers, the checker assumes that the variable can be modified. Pointers that point to these variables are not flagged.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declaration

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M7-3-1

The global namespace shall only contain main, namespace declarations and extern "C" declarations.

Description

Rule Definition

The global namespace shall only contain main, namespace declarations and extern "C" declarations.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declaration

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M7-3-2

The identifier main shall not be used for a function other than the global function main.

Description

Rule Definition

The identifier main shall not be used for a function other than the global function main.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declaration

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M7-3-3

There shall be no unnamed namespaces in header files.

Description

Rule Definition

There shall be no unnamed namespaces in header files.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declaration

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M7-3-4

Using-directives shall not be used.

Description

Rule Definition

using-directives shall not be used.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declaration

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M7-3-6

Using-directives and using-declarations (excluding class scope or function scope using-declarations) shall not be used in header files.

Description

Rule Definition

using-directives and using-declarations (excluding class scope or function scope using-declarations) shall not be used in header files.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declaration

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M7-4-2

Assembler instructions shall only be introduced using the asm declaration.

Description

Rule Definition

Assembler instructions shall only be introduced using the asm declaration.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declaration

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M7-4-3

Assembly language shall be encapsulated and isolated.

Description

Rule Definition

Assembly language shall be encapsulated and isolated.

Polyspace Implementation

The checker flags `asm` statements unless they are encapsulated in a function call.

For instance, the noncompliant `asm` statement below is in regular C code while the compliant `asm` statement is encapsulated in a call to the function `Delay`.

```
void Delay ( void )
  {
    asm( "NOP");//Compliant
  }
void fn (void)
  {
    DoSomething();
    Delay();// Assembler is encapsulated
    DoSomething();
    asm("NOP"); //Noncompliant
    DoSomething();
  }
```

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declaration

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M7-5-1

A function shall not return a reference or a pointer to an automatic variable (including parameters), defined within the function.

Description

Rule Definition

A function shall not return a reference or a pointer to an automatic variable (including parameters), defined within the function.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declaration

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M8-0-1

An init-declarator-list or a member-declarator-list shall consist of a single init-declarator or member-declarator respectively.

Description

Rule Definition

An init-declarator-list or a member-declarator-list shall consist of a single init-declarator or member-declarator respectively.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarators

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M8-3-1

Parameters in an overriding virtual function shall either use the same default arguments as the function they override, or else shall not specify any default arguments.

Description

Rule Definition

Parameters in an overriding virtual function shall either use the same default arguments as the function they override, or else shall not specify any default arguments.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarators

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M8-4-2

The identifiers used for the parameters in a re-declaration of a function shall be identical to those in the declaration.

Description

Rule Definition

The identifiers used for the parameters in a re-declaration of a function shall be identical to those in the declaration.

Polyspace Implementation

The checker detects mismatch in parameter names between:

- A function declaration and the corresponding definition.
- Two declarations of a function, provided they occur in the same file.

  If the declarations occur in different files, the checker does not raise a violation for mismatch in parameter names. Redeclarations in different files are forbidden by `AUTOSAR C++14 Rule M3-2-3`.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarators

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M8-4-4

A function identifier shall either be used to call the function or it shall be preceded by &.

Description

Rule Definition

A function identifier shall either be used to call the function or it shall be preceded by &.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarators

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M8-5-2

Braces shall be used to indicate and match the structure in the non-zero initialization of arrays and structures.

Description

Rule Definition

Braces shall be used to indicate and match the structure in the non- zero initialization of arrays and structures.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Declarators

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M9-3-1

Const member functions shall not return non-const pointers or references to class-data.

Description

Rule Definition

const member functions shall not return non-const pointers or references to class-data.

Polyspace Implementation

The checker flags a rule violation only if a `const` member function returns a non-`const` pointer or reference to a nonstatic data member. The rule does not apply to static data members.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Classes

See Also

Introduced in R2019a

AUTOSAR C++14 Rule M9-3-3

If a member function can be made static then it shall be made static, otherwise if it can be made const then it shall be made const.

Description

Rule Definition

If a member function can be made static then it shall be made static, otherwise if it can be made const then it shall be made const.

Polyspace Implementation

The checker flags member functions that are not declared static but do not access a data member of the class. Such a function can be potentially declared static.

The checker flags member functions that are not declared const but do not modify a data member of the class. Such a function can be potentially declared const.

Troubleshooting

If you expect a rule violation but do not see it, refer to The documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Check Information

Group: Classes

See Also

Introduced in R2019a

7

ISO/IEC TS 17961

Acknowledgment

Extracts from the standard "ISO/IEC TS 17961 Technical Specification - 2013-11-15" are reproduced with the agreement of AFNOR. Only the original and complete text of the standard, as published by AFNOR Editions - accessible via the website www.boutique.afnor.org - has normative value.

ISO/IEC TS 17961 [accfree]

Accessing freed memory

Description

Rule Definition

Accessing freed memory.

Examples

Use of previously freed pointer

Description

Use of previously freed pointer occurs when you access a block of memory after freeing the block using the `free` function.

Risk

When a pointer is allocated dynamic memory with `malloc`, `calloc` or `realloc`, it points to a memory location on the heap. When you use the `free` function on this pointer, the associated block of memory is freed for reallocation. Trying to access this block of memory can result in unpredictable behavior or even a segmentation fault.

Fix

The fix depends on the root cause of the defect. See if you intended to free the memory later or allocate another memory block to the pointer before access.

As a good practice, after you free a memory block, assign the corresponding pointer to NULL. Before dereferencing pointers, check them for NULL values and handle the error. In this way, you are protected against accessing a freed block.

Example - Use of Previously Freed Pointer Error

```
#include <stdlib.h>
#include <stdio.h>
 int increment_content_of_address(int base_val, int shift)
   {
    int j;
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return 0;

    *pi = base_val;
    free(pi);

    j = *pi + shift;
    /* Defect: Reading a freed pointer */

    return j;
   }
```

The `free` statement releases the block of memory that `pi` refers to. Therefore, dereferencing`pi` after the `free` statement is not valid.

Correction — Free Pointer After Use

One possible correction is to free the pointer `pi` only after the last instance where it is accessed.

```
#include <stdlib.h>

int increment_content_of_address(int base_val, int shift)
{
    int j;
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return 0;

    *pi = base_val;

    j = *pi + shift;
    *pi = 0;

    /* Fix: The pointer is freed after its last use */
    free(pi);
    return j;
}
```

Invalid use of standard library string routine

Description

Invalid use of standard library string routine occurs when a string library function is called with invalid arguments.

Risk

The risk depends on the type of invalid arguments. For instance, using the `strcpy` function with a source argument larger than the destination argument can result in buffer overflows.

Fix

The fix depends on the standard library function involved in the defect. In some cases, you can constrain the function arguments before the function call. For instance, if the `strcpy` function:

```
char * strcpy(char * destination, const char* source)
```

tries to copy too many bytes into the destination argument compared to the available buffer, constrain the source argument before the call to `strcpy`. In some cases, you can use an alternative function to avoid the error. For instance, instead of `strcpy`, you can use `strncpy` to control the number of bytes copied. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Invalid Use of Standard Library String Routine Error

```
#include <string.h>
#include <stdio.h>

char* Copy_String(void)
{
 char *res;
 char gbuffer[5],text[20]="ABCDEFGHIJKL";

 res=strcpy(gbuffer,text);
 /* Error: Size of text is less than gbuffer */
```

```
  return(res);
 }
```

The string `text` is larger in size than `gbuffer`. Therefore, the function `strcpy` cannot copy `text` into `gbuffer`.

Correction — Use Valid Arguments

One possible correction is to declare the destination string `gbuffer` with equal or larger size than the source string `text`.

```
#include <string.h>
 #include <stdio.h>

 char* Copy_String(void)
 {
  char *res;
  /*Fix: gbuffer has equal or larger size than text */
  char gbuffer[20],text[20]="ABCDEFGHIJKL";

  res=strcpy(gbuffer,text);

  return(res);
 }
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [accsig]

Accessing shared objects in signal handlers

Description

Rule Definition

Accessing shared objects in signal handlers.

Examples

Shared data access within signal handler

Description

Shared data access within signal handler occurs when you access or modify a shared object inside a signal handler.

Risk

When you define a signal handler function to access or modify a shared object, the handler accesses or modifies the shared object when it receives a signal. If another function is already accessing the shared object, that function causes a race condition and can leave the data in an inconsistent state.

Fix

To access or modify shared objects inside a signal handler, check that the objects are lock-free atomic, or, if they are integers, declare them as `volatile sig_atomic_t`.

Example - `int` Variable Access in Signal Handler

```
#include <signal.h>
#include <stdlib.h>
#include <string.h>
```

```
/* declare global variable. */
int e_flag;

void sig_handler(int signum)
{
    /* Signal handler accesses variable that is not
    of type volatile sig_atomic_t. */
    e_flag = signum;
}

int func(void)
{
    if (signal(SIGINT, sig_handler) == SIG_ERR)
    {
        /* Handle error */
        abort();
    }
    /* Program code */
    if (raise(SIGINT) != 0)
    {
        /* Handle error */
        abort();
    }
    /* More code */
    return 0;
}
```

In this example, `sig_handler` accesses `e_flag`, a variable of type `int`. A concurrent access by another function can leave `e_flag` in an inconsistent state.

Correction — Declare Variable of Type `volatile sig_atomic_t`

Before you access a shared variable from a signal handler, declare the variable with type `volatile sig_atomic_t` instead of `int`. You can safely access variables of this type asynchronously.

```
#include <signal.h>
#include <stdlib.h>
#include <string.h>

/* Declare variable of type volatile sig_atomic_t. */
```

```
volatile sig_atomic_t e_flag;
void sig_handler(int signum)
{
    /* Use variable of proper type inside signal handler. */
    e_flag = signum;

}

int func(void)
{
    if (signal(SIGINT, sig_handler) == SIG_ERR)
    {
        /* Handle error */
        abort();
    }
    /* Program code */
    if (raise(SIGINT) != 0)
    {
        /* Handle error */
        abort();
    }
    /* More code */
    return 0;
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [addrescape]

Escaping of the address of an automatic object

Description

Rule Definition

Escaping of the address of an automatic object.

Examples

Pointer or reference to stack variable leaving scope

Description

Pointer or reference to stack variable leaving scope occurs when a pointer or reference to a local variable leaves the scope of the variable. For instance:

- A function returns a pointer to a local variable.
- A function performs the assignment `globPtr = &locVar`. `globPtr` is a global pointer variable and `locVar` is a local variable.
- A function performs the assignment `*paramPtr = &locVar`. `paramPtr` is a function parameter that is, for instance, an `int**` pointer and `locVar` is a local `int` variable.
- A C++ method performs the assignment `memPtr = &locVar`. `memPtr` is a pointer data member of the class the method belongs to. `locVar` is a variable local to the method.

The defect also applies to memory allocated using the `alloca` function. The defect does not apply to static, local variables.

Risk

Local variables are allocated an address on the stack. Once the scope of a local variable ends, this address is available for reuse. Using this address to access the local variable value outside the variable scope can cause unexpected behavior.

If a pointer to a local variable leaves the scope of the variable, Polyspace Bug Finder highlights the defect. The defect appears even if you do not use the address stored in the pointer. For maintainable code, it is a good practice to not allow the pointer to leave the variable scope. Even if you do not use the address in the pointer now, someone else using your function can use the address, causing undefined behavior.

Fix

Do not allow a pointer or reference to a local variable to leave the variable scope.

Example - Pointer to Local Variable Returned from Function

```
void func2(int *ptr) {
    *ptr = 0;
}

int* func1(void) {
    int ret = 0;
    return &ret ;
}
void main(void) {
    int* ptr = func1() ;
    func2(ptr) ;
}
```

In this example, `func1` returns a pointer to local variable `ret`.

In `main`, `ptr` points to the address of the local variable. When `ptr` is accessed in `func2`, the access is illegal because the scope of `ret` is limited to `func1`,

Use of automatic variable as putenv-family function argument

Description

Use of automatic variable as `putenv`-family function argument occurs when the argument of a `putenv`-family function is a local variable with automatic duration.

Risk

The function `putenv(char *string)` inserts a pointer to its supplied argument into the environment array, instead of making a copy of the argument. If the argument is an automatic variable, its memory can be overwritten after the function containing the `putenv()` call returns. A subsequent call to `getenv()` from another function returns the address of an out-of-scope variable that cannot be dereferenced legally. This out-of-scope variable can cause environment variables to take on unexpected values, cause the program to stop responding, or allow arbitrary code execution vulnerabilities.

Fix

Use `setenv()`/`unsetenv()` to set and unset environment variables. Alternatively, use `putenv`-family function arguments with dynamically allocated memory, or, if your application has no reentrancy requirements, arguments with static duration. For example, a single thread execution with no recursion or interrupts does not require reentrancy. It cannot be called (reentered) during its execution.

Example - Automatic Variable as Argument of `putenv()`

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define SIZE1024 1024

void func(int var)
{
    char env[SIZE1024];
    int retval = sprintf(env, "TEST=%s", var ? "1" : "0");
    if (retval <= 0) {
        /* Handle error */
    }
    /* Environment variable TEST is set using putenv().
    The argument passed to putenv is an automatic variable. */
    retval = putenv(env);
    if (retval != 0) {
        /* Handle error */
    }
}
```

In this example, `sprintf()` stores the character string `TEST=var` in `env`. The value of the environment variable `TEST` is then set to `var` by using `putenv()`. Because `env` is an automatic variable, the value of `TEST` can change once `func()` returns.

Correction — Use `static` Variable for Argument of `putenv()`

Declare `env` as a static-duration variable. The memory location of `env` is not overwritten for the duration of the program, even after `func()` returns.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define SIZE1024 1024
void func(int var)
{
    /* static duration variable */
    static char env[SIZE1024];
    int retval = sprintf(env,"TEST=%s", var ? "1" : "0");
    if (retval <= 0) {
        /* Handle error */
    }

    /* Environment variable TEST is set using putenv() */
    retval=putenv(env);
    if (retval != 0) {
        /* Handle error */
    }
}
```

Correction — Use `setenv()` to Set Environment Variable Value

To set the value of `TEST` to `var`, use `setenv()`.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define SIZE1024 1024

void func(int var)
{
    /* Environment variable TEST is set using setenv() */
    int retval = setenv("TEST", var ? "1" : "0", 1);
```

```
    if (retval != 0) {
        /* Handle error */
    }
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [alignconv]

Converting pointer values to more strictly aligned pointer types

Description

Rule Definition

Converting pointer values to more strictly aligned pointer types.

Examples

Wrong allocated object size for cast

Description

Wrong allocated object size for cast occurs during pointer conversion when the pointer's address is misaligned. If a pointer is converted to a different pointer type, the size of the allocated memory must be a multiple of the size of the destination pointer.

Risk

Dereferencing a misaligned pointer has undefined behavior and can cause your program to crash.

Fix

Suppose you convert a pointer `ptr1` to `ptr2`. If `ptr1` points to a buffer of `N` bytes and `ptr2` is a *`type`* `*` pointer where `sizeof(`*`type`*`)` is `n` bytes, make sure that `N` is an integer multiple of `n`.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See "Address Polyspace Results Through Bug Fixes or Comments".

Example - Dynamic Allocation of Pointers

```
#include <stdlib.h>

void dyn_non_align(void){
    void *ptr = malloc(13);
    long *dest;

    dest = (long*)ptr; //defect
}
```

In this example, the software raises a defect on the conversion of `ptr` to a `long*`. The dynamically allocated memory of `ptr`, 13 bytes, is not a multiple of the size of `dest`, 4 bytes. This misalignment causes the **Wrong allocated object size for cast** defect.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the allocated memory to 12 instead of 13.

```
#include <stdlib.h>

void dyn_non_align(void){
    void *ptr = malloc(12);
    long *dest;

    dest = (long*)ptr;
}
```

Example - Static Allocation of Pointers

```
void static_non_align(void){
    char arr[13], *ptr;
    int *dest;

    ptr = &arr[0];
    dest = (int*)ptr; //defect
}
```

In this example, the software raises a defect on the conversion of `ptr` to an `int*` in line 6. `ptr` has a memory size of 13 bytes because the array `arr` has a size of 13 bytes. The size of `dest` is 4 bytes, which is not a multiple of 13. This misalignment causes the **Wrong allocated object size for cast** defect.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the size of the array `arr` to a multiple of 4.

```
void static_non_align(void){
    char arr[12], *ptr;
    int *dest;

    ptr = &arr[0];
    dest = (int*)ptr;
}
```

Example - Allocation with a Function

```
#include <stdlib.h>

void *my_alloc(int size) {
    void *ptr_func = malloc(size);
    if(ptr_func == NULL) exit(-1);
    return ptr_func;
}

void fun_non_align(void){
    int *dest1;
    char *dest2;

    dest1 = (int*)my_alloc(13);  //defect
    dest2 = (char*)my_alloc(13); //not a defect
}
```

In this example, the software raises a defect on the conversion of the pointer returned by `my_alloc(13)` to an `int*` in line 11. `my_alloc(13)` returns a pointer with a dynamically allocated size of 13 bytes. The size of `dest1` is 4 bytes, which is not a divisor of 13. This misalignment causes the **Wrong allocated object size for cast** defect. In line 12, the same function call, `my_alloc(13)`, does not call a defect for the conversion to `dest2` because the size of `char*`, 1 byte, a divisor of 13.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the argument for `my_alloc` to a multiple of 4.

```
#include <stdlib.h>

void *my_alloc(int size) {
    void *ptr_func = malloc(size);
    if(ptr_func == NULL) exit(-1);
    return ptr_func;
}

void fun_non_align(void){
    int *dest1;
    char *dest2;

    dest1 = (int*)my_alloc(12);
    dest2 = (char*)my_alloc(13);
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [argcomp]

Calling functions with incorrect arguments

Description

Rule Definition

Calling functions with incorrect arguments.

Examples

Conflicting declarations or conflicting declaration and definition

Description

The issue occurs when all declarations of an object or function do not use the same names and type qualifiers.

The rule checker detects situations where parameter names or data types are different between multiple declarations or the declaration and the definition. The checker considers declarations in all translation units and flags issues that are not likely to be detected by a compiler.

Polyspace Bug Finder and Polyspace Code Prover check this coding rule differently. The analyses can produce different results.

Risk

Consistently using parameter names and types across declarations of the same object or function encourages stronger typing. It is easier to check that the same function interface is used across all declarations.

Example - Mismatch in Parameter Names

```
extern int div (int num, int den);

int div(int den, int num) { /* Non compliant */
    return(num/den);
}
```

In this example, the rule is violated because the parameter names in the declaration and definition are switched.

Example - Mismatch in Parameter Data Types

```
typedef unsigned short width;
typedef unsigned short height;
typedef unsigned int area;

extern area calculate(width w, height h);

area calculate(width w, width h) { /* Non compliant *
    return w*h;
}
```

In this example, the rule is violated because the second argument of the `calculate` function has data type:

- `height` in the declaration.
- `width` in the definition.

The rule is violated even though the underlying type of `height` and `width` are identical.

Unreliable cast of function pointer

Description

Unreliable cast of function pointer occurs when a function pointer is cast to another function pointer that has different argument or return type.

This defect applies only if the code language for the project is C.

Risk

If you cast a function pointer to another function pointer with different argument or return type and then use the latter function pointer to call a function, the behavior is undefined.

Fix

Avoid a cast between two function pointers with mismatch in argument or return types.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Unreliable cast of function pointer error

```
#include <stdio.h>
#include <math.h>
#include <stdio.h>
#define PI 3.142

double Calculate_Sum(int (*fptr)(double))
{
    double  sum = 0.0;
    double  y;

    for (int i = 0;  i <= 100;  i++)
    {
        y = (*fptr)(i*PI/100);
        sum += y;
    }
    return sum / 100;
}

int main(void)
{
    double  (*fp)(double);
    double  sum;

    fp = sin;
    sum = Calculate_Sum(fp);
    /* Defect: fp implicitly cast to int(*) (double) */
```

```
    printf("sum(sin): %f\n", sum);
    return 0;
}
```

The function pointer `fp` is declared as `double (*)(double)`. However in passing it to function `Calculate_Sum`, `fp` is implicitly cast to `int (*)(double)`.

Correction — Avoid Function Pointer Cast

One possible correction is to check that the function pointer in the definition of `Calculate_Sum` has the same argument and return type as `fp`. This step makes sure that `fp` is not implicitly cast to a different argument or return type.

```
#include <stdio.h>
#include <math.h>
#include <stdio.h>
# define PI 3.142

/*Fix: fptr has same argument and return type everywhere*/
double Calculate_Sum(double (*fptr)(double))
{
    double  sum = 0.0;
    double y;

    for (int i = 0;  i <= 100;  i++)
    {
        y = (*fptr)(i*PI/100);
        sum += y;
    }
    return sum / 100;
}

int main(void)
{
    double  (*fp)(double);
    double  sum;


    fp = sin;
    sum = Calculate_Sum(fp);
    printf("sum(sin): %f\n", sum);

    return 0;
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [asyncsig]

Calling functions in the C Standard Library other than abort, _Exit, and signal from within a signal handler

Description

Rule Definition

Calling functions in the C Standard Library other than abort, _Exit, and signal from within a signal handler.

Examples

Function called from signal handler not asynchronous-safe (strict)

Description

Function called from signal handler not asynchronous-safe (strict) occurs when a signal handler calls a function that is not asynchronous-safe according to the C standard. An asynchronous-safe function can be interrupted at any point in its execution, then called again without causing an inconsistent state. It can also correctly handle global data that might be in an inconsistent state.

When you select the checker **Function called from signal handler not asynchronous-safe**, the checker detects calls to functions that are not asynchronous-safe according to the POSIX standard. **Function called from signal handler not asynchronous-safe (strict)** does not raise a defect for these cases. **Function called from signal handler not asynchronous-safe (strict)** raises a defect for functions that are asynchronous-safe according to the POSIX standard but not according to the C standard.

If a signal handler calls another function that calls an asynchronous-unsafe function, the defect appears on the function call in the signal handler. The defect traceback shows the full path from the signal handler to the asynchronous-unsafe function.

Risk

When a signal handler is invoked, the execution of the program is interrupted. After the handler is finished, program execution resumes at the point of interruption. If a function is executing at the time of the interruption, calling it from within the signal handler is undefined behavior, unless it is asynchronous-safe.

Fix

The C standard defines the following functions as asynchronous-safe. You can call these functions from a signal handler:

- `abort()`
- `_Exit()`
- `quick_exit()`
- `signal()`

Example - Call to `raise()` Inside Signal Handler

```
#include <signal.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <setjmp.h>
#include <syslog.h>
#include <unistd.h>

void SIG_ERR_handler(int signum)
{
    int s0 = signum;
    /* SIGTERM specific handling */
}

void sig_handler(int signum)
{
    int s0 = signum;
    /* Call raise() */
    if (raise(SIGTERM) != 0) {
        /* Handle error */
    }
}

int finc(void)
```

```
{
    if (signal(SIGTERM, SIG_ERR_handler) == SIG_ERR)
    {
        /* Handle error */
    }
    if (signal(SIGINT, sig_handler) == SIG_ERR)
    {
        /* Handle error */
    }
    /* Program code */
    if (raise(SIGINT) != 0)
    {
        /* Handle error */
    }
    /* More code */
    return 0;
}
```

In this example, `sig_handler` calls `raise()` when catching a signal. If the handler catches another signal while `raise()` is executing, the behavior of the program is undefined.

Correction — Remove Call to `raise()` in Signal Handler

According to the C standard, the only functions that you can safely call from a signal handler are `abort()`, `_Exit()`, `quick_exit()`, and `signal()`.

```
#include <signal.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <setjmp.h>
#include <syslog.h>
#include <unistd.h>

void SIG_ERR_handler(int signum)
{
    int s0 = signum;
    /* SIGTERM specific handling */
}
void sig_handler(int signum)
{
```

```
    int s0 = signum;


}

int func(void)
{
    if (signal(SIGTERM, SIG_ERR_handler) == SIG_ERR)
    {
        /* Handle error */
    }
    if (signal(SIGINT, sig_handler) == SIG_ERR)
    {
        /* Handle error */
    }
    /* Program code */
    if (raise(SIGINT) != 0)
    {
        /* Handle error */
    }
    /* More code */
    return 0;
}
```

Function called from signal handler not asynchronous-safe

Description

Function called from signal handler not asynchronous-safe occurs when a signal handler calls a function that is not asynchronous-safe according to the POSIX standard. An asynchronous-safe function can be interrupted at any point in its execution, then called again without causing an inconsistent state. It can also correctly handle global data that might be in an inconsistent state.

If a signal handler calls another function that calls an asynchronous-unsafe function, the defect appears on the function call in the signal handler. The defect traceback shows the full path from the signal handler to the asynchronous-unsafe function.

Risk

When a signal handler is invoked, the execution of the program is interrupted. After the handler is finished, program execution resumes at the point of interruption. If a function

is executing at the time of the interruption, calling it from within the signal handler is undefined behavior, unless it is asynchronous-safe.

Fix

The POSIX standard defines these functions as asynchronous-safe. You can call these functions from a signal handler.

`_exit()`	`getpgrp()`	`setsockopt()`
`_Exit()`	`getpid()`	`setuid()`
`abort()`	`getppid()`	`shutdown()`
`accept()`	`getsockname()`	`sigaction()`
`access()`	`getsockopt()`	`sigaddset()`
`aio_error()`	`getuid()`	`sigdelset()`
`aio_return()`	`kill()`	`sigemptyset()`
`aio_suspend()`	`link()`	`sigfillset()`
`alarm()`	`linkat()`	`sigismember()`
`bind()`	`listen()`	`signal()`
`cfgetispeed()`	`lseek()`	`sigpause()`
`cfgetospeed()`	`lstat()`	`sigpending()`
`cfsetispeed()`	`mkdir()`	`sigprocmask()`
`cfsetospeed()`	`mkdirat()`	`sigqueue()`
`chdir()`	`mkfifo()`	`sigset()`
`chmod()`	`mkfifoat()`	`sigsuspend()`
`chown()`	`mknod()`	`sleep()`
`clock_gettime()`	`mknodat()`	`sockatmark()`
`close()`	`open()`	`socket()`
`connect()`	`openat()`	`socketpair()`
`creat()`	`pathconf()`	`stat()`
`dup()`	`pause()`	`symlink()`
`dup2()`	`pipe()`	`symlinkat()`

execl()	poll()	sysconf()
execle()	posix_trace_event()	tcdrain()
execv()	pselect()	tcflow()
execve()	pthread_kill()	tcflush()
faccessat()	pthread_self()	tcgetattr()
fchdir()	pthread_sigmask()	tcgetpgrp()
fchmod()	quick_exit()	tcsendbreak()
fchmodat()	raise()	tcsetattr()
fchown()	read()	tcsetpgrp()
fchownat()	readlink()	time()
fcntl()	readlinkat()	timer_getoverrun()
fdatasync()	recv()	timer_gettime()
fexecve()	recvfrom()	timer_settime()
fork()	recvmsg()	times()
fpathconf()	rename()	umask()
fstat()	renameat()	uname()
fstatat()	rmdir()	unlink()
fsync()	select()	unlinkat()
ftruncate()	sem_post()	utime()
futimens()	send()	utimensat()
getegid()	sendmsg()	utimes()
geteuid()	sendto()	wait()
getgid()	setgid()	waitpid()
getgroups()	setpgid()	write()
getpeername()	setsid()	

Functions not in the previous table are not asynchronous-safe, and should not be called from a signal hander.

Example - Call to `printf()` Inside Signal Handler

```
#include <signal.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <setjmp.h>
#include <syslog.h>
#include <unistd.h>

#define SIZE20 20

extern volatile sig_atomic_t e_flag;

void display_info(const char *info)
{
    if (info)
    {
        (void)fputs(info, stderr);
    }
}

void sig_handler(int signum)
{
    /* Call function printf() that is not
    asynchronous-safe */
    printf("signal %d received.", signum);
    e_flag = 1;
}

int main(void)
{
    e_flag = 0;
    if (signal(SIGINT, sig_handler) == SIG_ERR)
    {
        /* Handle error */
    }
    char *info = (char *)calloc(SIZE20, sizeof(char));
    if (info == NULL)
    {
        /* Handle Error */
    }
    while (!e_flag)
    {
```

```
        /* Main loop program code */
        display_info(info);
        /* More program code */
    }
    free(info);
    info = NULL;
    return 0;
}
```

In this example, `sig_handler` calls `printf()` when catching a signal. If the handler catches another signal while `printf()` is executing, the behavior of the program is undefined.

Correction — Set Flag Only in Signal Handler

Use your signal handler to set only the value of a flag. `e_flag` is of type volatile `sig_atomic_t`. `sig_handler` can safely access it asynchronously.

```
#include <signal.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <setjmp.h>
#include <syslog.h>
#include <unistd.h>

#define SIZE20 20

extern volatile sig_atomic_t e_flag;

void display_info(const char *info)
{
    if (info)
    {
        (void)fputs(info, stderr);
    }
}

void sig_handler1(int signum)
{
    int s0 = signum;
    e_flag = 1;
```

```
}

int func(void)
{
    e_flag = 0;
    if (signal(SIGINT, sig_handler1) == SIG_ERR)
    {
        /* Handle error */
    }
    char *info = (char *)calloc(SIZE20, 1);
    if (info == NULL)
    {
        /* Handle error */
    }
    while (!e_flag)
    {
        /* Main loop program code */
        display_info(info);
        /* More program code */
    }
    free(info);
    info = NULL;
    return 0;
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [boolasgn]

No assignment in conditional expressions

Description

Rule Definition

No assignment in conditional expressions.

Examples

Invalid use of = (assignment) operator

Description

Invalid use of = operator occurs when an assignment is made inside the predicate of a conditional, such as `if` or `while`.

In C and C++, a single equal sign is an assignment not a comparison. Using a single equal sign in a conditional statement can indicate a typo or a mistake.

Risk

- Conditional statement tests the wrong values— The single equal sign operation assigns the value of the right operand to the left operand. Then, because this assignment is inside the predicate of a conditional, the program checks whether the new value of the left operand is nonzero or not NULL.
- Maintenance and readability issues — Even if the assignment is intended, someone reading or updating the code can misinterpret the assignment as an equality comparison instead of an assignment.

Fix

- If the assignment is a bug, to check for equality, add a second equal sign (==).

- If the assignment inside the conditional statement was intentional, to improve readability, separate the assignment and the test. Move the assignment outside the control statement. In the control statement, simply test the result of the assignment.

  If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Single Equal Sign Inside an `if` Condition

```
#include <stdio.h>

void bad_equals_ex(int alpha, int beta)
{
    if(alpha = beta)
    {
        printf("Equal\n");
    }
}
```

The equal sign is flagged as a defect because the assignment operator is used within the predicate of the if-statement. The predicate assigns the value `beta` to `alpha`, then implicitly tests whether `alpha` is true or false.

Correction — Change Expression to Comparison

One possible correction is adding an additional equal sign. This correction changes the assignment to a comparison. The if condition compares whether `alpha` and `beta` are equal.

```
#include <stdio.h>

void equality_test(int alpha, int beta)
{
    if(alpha == beta)
    {
        printf("Equal\n");
    }
}
```

Correction — Assignment and Comparison Inside the `if` Condition

If an assignment must be made inside the predicate, a possible correction is adding an explicit comparison. This correction assigns the value of `beta` to `alpha`, then explicitly checks whether `alpha` is nonzero. The code is clearer.

```
#include <stdio.h>

int assignment_not_zero(int alpha, int beta)
{
    if((alpha = beta) != 0)
    {
        return alpha;
    }
    else
    {
        return 0;
    }
}
```

Correction — Move Assignment Outside the `if` Statement

If the assignment can be made outside the control statement, one possible correction is to separate the assignment and comparison. This correction assigns the value of `beta` to `alpha` before the if. Inside the if-condition, only `alpha` is given to test if `alpha` is nonzero or not NULL.

```
#include <stdio.h>

void assign_and_print(int alpha, int beta)
{
    alpha = beta;
    if(alpha)
    {
        printf("%d", alpha);
    }
}
```

Check Information

Decidability: Decidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [chreof]

Using character values that are indistinguishable from EOF

Description

Rule Definition

Using character values that are indistinguishable from EOF.

Examples

Character value absorbed into EOF

Description

Character value absorbed into EOF occurs when you perform a data type conversion that makes a valid character value indistinguishable from `EOF` (End-of-File). Bug Finder flags the defect in one of the following situations:

- *End-of-File*: You perform a data type conversion such as from `int` to `char` that converts a non-EOF character value into `EOF`.

  ```
  char ch = (char)getchar()
  ```

  You then compare the result with EOF.

  ```
  if((int)ch == EOF)
  ```

  The conversion can be explicit or implicit.
- *Wide End-of-File*: You perform a data type conversion that can convert a non-WEOF wide character value into WEOF, and then compare the result with WEOF.

Risk

The data type `char` cannot hold the value `EOF` that indicates the end of a file. Functions such as `getchar` have return type `int` to accommodate `EOF`. If you convert from `int` to

`char`, the values `UCHAR_MAX` (a valid character value) and `EOF` get converted to the same value -1 and become indistinguishable from each other. When you compare the result of this conversion with `EOF`, the comparison can lead to false detection of `EOF`. This rationale also applies to wide character values and `WEOF`.

Fix

Perform the comparison with `EOF` or `WEOF` before conversion.

Example - Return Value of `getchar` Converted to `char`

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

char func(void)
{
    char ch;
    ch = getchar();
    if (EOF == (int)ch) {
        fatal_error();
    }
    return ch;
}
```

In this example, the return value of `getchar` is implicitly converted to `char`. If `getchar` returns `UCHAR_MAX`, it is converted to -1, which is indistinguishable from EOF. When you compare with EOF later, it can lead to a false positive.

Correction — Perform Comparison with EOF Before Conversion

One possible correction is to first perform the comparison with EOF, and then convert from `int` to `char`.

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

char func(void)
{
    int i;
    i = getchar();
    if (EOF == i) {
        fatal_error();
```

```
    }
    else {
        return (char)i;
    }
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [chrsgnext]

Passing arguments to character handling functions that are not representable as unsigned char

Description

Rule Definition

Passing arguments to character handling functions that are not representable as unsigned char.

Examples

Invalid use of standard library integer routine

Description

Invalid use of standard library integer routine occurs when you use invalid arguments with an integer function from the standard library. This defect picks up:

- Character Conversion

  ```
  toupper, tolower
  ```

- Character Checks

  ```
  isalnum, isalpha, iscntrl, isdigit, isgraph, islower, isprint,
  ispunct, isspace, isupper, isxdigit
  ```

- Integer Division

  ```
  div, ldiv
  ```

- Absolute Values

  ```
  abs, labs
  ```

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Absolute Value of Large Negative

```
#include <limits.h>
#include <stdlib.h>

int absoluteValue(void) {

    int neg = INT_MIN;
    return abs(neg);
}
```

The input value to `abs` is `INT_MIN`. The absolute value of `INT_MIN` is `INT_MAX+1`. This number cannot be represented by the type `int`.

Correction — Change Input Argument

One possible correction is to change the input value to fit returned data type. In this example, change the input value to `INT_MIN+1`.

```
#include <limits.h>
#include <stdlib.h>

int absoluteValue(void) {

    int neg = INT_MIN+1;
    return abs(neg);
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [dblfree]

Freeing memory multiple times

Description

Rule Definition

Freeing memory multiple times.

Examples

Deallocation of previously deallocated pointer

Description

Deallocation of previously deallocated pointer occurs when a block of memory is freed more than once using the `free` function without an intermediate allocation.

Risk

When a pointer is allocated dynamic memory with `malloc`, `calloc` or `realloc`, it points to a memory location on the heap. When you use the `free` function on this pointer, the associated block of memory is freed for reallocation. Trying to free this block of memory can result in a segmentation fault.

Fix

The fix depends on the root cause of the defect. See if you intended to allocate a memory block to the pointer between the first deallocation and the second. Otherwise, remove the second `free` statement.

As a good practice, after you free a memory block, assign the corresponding pointer to NULL. Before freeing pointers, check them for NULL values and handle the error. In this way, you are protected against freeing an already freed block.

Example - Deallocation of Previously Deallocated Pointer Error

```
#include <stdlib.h>

void allocate_and_free(void)
{

    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return;

    *pi = 2;
    free(pi);
    free (pi);
    /* Defect: pi has already been freed */
}
```

The first `free` statement releases the block of memory that `pi` refers to. The second `free` statement on `pi` releases a block of memory that has been freed already.

Correction — Remove Duplicate Deallocation

One possible correction is to remove the second `free` statement.

```
#include <stdlib.h>

void allocate_and_free(void)
{

    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL) return;

    *pi = 2;
    free(pi);
    /* Fix: remove second deallocation */
 }
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [diverr]

Integer division errors

Description

Rule Definition

Integer division errors.

Examples

Integer division by zero

Description

Integer division by zero occurs when the denominator of a division or modulo operation can be a zero-valued integer.

Risk

A division by zero can result in a program crash.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the denominator variable acquires a zero value. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

It is a good practice to check for zero values of a denominator before division and handle the error. Instead of performing the division directly:

```
res = num/den;
```

use a library function that handles zero values of the denominator before performing the division:

```
res = div(num, den);
```

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Dividing an Integer by Zero

```
int fraction(int num)
{
    int denom = 0;
    int result = 0;

    result = num/denom;

    return result;
}
```

A division by zero error occurs at `num/denom` because `denom` is zero.

Correction — Check Before Division

```
int fraction(int num)
{
    int denom = 0;
    int result = 0;

    if (denom != 0)
        result = num/denom;

    return result;
}
```

Before dividing, add a test to see if the denominator is zero, checking before division occurs. If `denom` is always zero, this correction can produce a dead code defect in your Polyspace results.

Correction — Change Denominator

One possible correction is to change the denominator value so that `denom` is not zero.

```
int fraction(int num)
{
    int denom = 2;
    int result = 0;

    result = num/denom;

    return result;
}
```

Example - Modulo Operation with Zero

```
int mod_arr(int input)
{
    int arr[5];
    for(int i = 0; i < 5; i++)
    {
        arr[i] = input % i;
    }

    return arr[0]+arr[1]+arr[2]+arr[3]+arr[4];
}
```

In this example, Polyspace flags the modulo operation as a division by zero. Because modulo is inherently a division operation, the divisor (right hand argument) cannot be zero. The modulo operation uses the `for` loop index as the divisor. However, the `for` loop starts at zero, which cannot be an iterator.

Correction — Check Divisor Before Operation

One possible correction is checking the divisor before the modulo operation. In this example, see if the index `i` is zero before the modulo operation.

```
int mod_arr(int input)
{
    int arr[5];
    for(int i = 0; i < 5; i++)
    {
        if(i != 0)
        {
             arr[i] = input % i;
        }
        else
        {
```

```
            arr[i] = input;
        }
    }

    return arr[0]+arr[1]+arr[2]+arr[3]+arr[4];
}
```

Correction — Change Divisor

Another possible correction is changing the divisor to a nonzero integer. In this example, add one to the index before the `%` operation to avoid dividing by zero.

```
int mod_arr(int input)
{
    int arr[5];
    for(int i = 0; i < 5; i++)
    {
         arr[i] = input % (i+1);
    }

    return arr[0]+arr[1]+arr[2]+arr[3]+arr[4];
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [fileclose]

Failing to close files or free dynamic memory when they are no longer needed

Description

Rule Definition

Failing to close files or free dynamic memory when they are no longer needed.

Examples

Memory leak

Description

Memory leak occurs when you do not free a block of memory allocated through `malloc`, `calloc`, `realloc`, or `new`. If the memory is allocated in a function, the defect does not occur if:

- Within the function, you free the memory using `free` or `delete`.
- The function returns the pointer assigned by `malloc`, `calloc`, `realloc`, or `new`.
- The function stores the pointer in a global variable or in a parameter.

Risk

Dynamic memory allocation functions such as `malloc` allocate memory on the heap. If you do not release the memory after use, you reduce the amount of memory available for another allocation. On embedded systems with limited memory, you might end up exhausting available heap memory even during program execution.

Fix

Determine the scope where the dynamically allocated memory is accessed. Free the memory block at the end of this scope.

To free a block of memory, use the `free` function on the pointer that was used during memory allocation. For instance:

```
ptr = (int*)malloc(sizeof(int));
...
free(ptr);
```

It is a good practice to allocate and free memory in the same module at the same level of abstraction. For instance, in this example, `func` allocates and frees memory at the same level but `func2` does not.

```
void func() {
  ptr = (int*)malloc(sizeof(int));
  {
    ...
  }
  free(ptr);
}

void func2() {
  {
   ptr = (int*)malloc(sizeof(int));
   ...
  }
  free(ptr);
}
```

See CERT-C Rule MEM00-C.

Example - Dynamic Memory Not Released Before End of Function

```
#include<stdlib.h>
#include<stdio.h>

void assign_memory(void)
{
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL)
        {
         printf("Memory allocation failed");
         return;
        }


    *pi = 42;
```

```
    /* Defect: pi is not freed */
}
```

In this example, `pi` is dynamically allocated by `malloc`. The function `assign_memory` does not free the memory, nor does it return `pi`.

Correction — Free Memory

One possible correction is to free the memory referenced by `pi` using the `free` function. The `free` function must be called before the function `assign_memory` terminates

```
#include<stdlib.h>
#include<stdio.h>

void assign_memory(void)
{
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL)
        {
         printf("Memory allocation failed");
         return;
        }
    *pi = 42;

    /* Fix: Free the pointer pi*/
    free(pi);
}
```

Correction — Return Pointer from Dynamic Allocation

Another possible correction is to return the pointer `pi`. Returning `pi` allows the function calling `assign_memory` to free the memory block using `pi`.

```
#include<stdlib.h>
#include<stdio.h>

int* assign_memory(void)
{
    int* pi = (int*)malloc(sizeof(int));
    if (pi == NULL)
        {
            printf("Memory allocation failed");
            return(pi);
        }
```

```
    *pi = 42;

    /* Fix: Return the pointer pi*/
    return(pi);
}
```

Example - Memory Leak with New/Delete

```
#define NULL '\0'

void initialize_arr1(void)
{
    int *p_scalar = new int(5);
}

void initialize_arr2(void)
{
    int *p_array = new int[5];
}
```

In this example, the functions create two variables, `p_scalar` and `p_array`, using the `new` keyword. However, the functions end without cleaning up the memory for these pointers. Because the functions used `new` to create these variables, you must clean up their memory by calling `delete` at the end of each function.

Correction — Add Delete

To correct this error, add a `delete` statement for every `new` initialization. If you used brackets `[]` to instantiate a variable, you must call delete with brackets as well.

```
#define NULL '\0'

void initialize_arrs(void)
{
    int *p_scalar = new int(5);
    int *p_array = new int[5];

    delete p_scalar;
    p_scalar = NULL;

    delete[] p_array;
    p_scalar = NULL;
}
```

Resource leak

Description

Resource leak occurs when you open a file stream by using a `FILE` pointer but do not close it before:

- The end of the pointer's scope.
- Assigning the pointer to another stream.

Risk

If you do not release file handles explicitly as soon as possible, a failure can occur due to exhaustion of resources.

Fix

Close a `FILE` pointer before the end of its scope, or before you assign the pointer to another stream.

Example - `FILE` Pointer Not Released Before End of Scope

```
#include <stdio.h>

void func1( void ) {
    FILE *fp1;
    fp1 = fopen ( "data1.txt", "w" );
    fprintf ( fp1, "*" );

    fp1 = fopen ( "data2.txt", "w" );
    fprintf ( fp1, "!" );
    fclose ( fp1 );
}
```

In this example, the file pointer `fp1` is pointing to a file `data1.txt`. Before `fp1` is explicitly dissociated from the file stream of `data1.txt`, it is used to access another file `data2.txt`.

Correction — Release `FILE` Pointer

One possible correction is to explicitly dissociate `fp1` from the file stream of `data1.txt`.

```
#include <stdio.h>
```

```
void func1( void ) {
    FILE *fp1;
    fp1 = fopen ( "data1.txt", "w" );
    fprintf ( fp1, "*" );
    fclose(fp1);

    fp1 = fopen ( "data2.txt", "w" );
    fprintf ( fp1, "!" );
    fclose ( fp1 );
}
```

Thread-specific memory leak

Description

Thread-specific memory leak occurs when you do not free thread-specific dynamically allocated memory before the end of a thread.

To create thread-specific storage, you generally do these steps:

1. You create a key for thread-specific storage.
2. You create the threads.
3. In each thread, you allocate storage dynamically and then associate the key with this storage.

   After the association, you can read the stored data later using the key.
4. Before the end of the thread, you free the thread-specific memory using the key.

The checker flags execution paths in the thread where the last step is missing.

The checker works on these families of functions:

- `tss_get` and `tss_set` (C11)
- `pthread_getspecific` and `pthread_setspecific` (POSIX)

Risk

The data stored in the memory is available to other processes even after the threads end (memory leak). Besides security vulnerabilities, memory leaks can shrink the amount of available memory and reduce performance.

Fix

Free dynamically allocated memory before the end of a thread.

You can explicitly free dynamically allocated memory with functions such as `free`.

Alternatively, when you create a key, you can associate a destructor function with the key. The destructor function is called with the key value as argument at the end of a thread. In the body of the destructor function, you can free any memory associated with the key. If you use this method, Bug Finder still flags a defect. Ignore this defect with appropriate comments. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Memory Not Freed at End of Thread

```
#include <threads.h>
#include <stdlib.h>

/* Global key to the thread-specific storage */
tss_t key;
enum { MAX_THREADS = 3 };


int add_data(void) {
  int *data = (int *)malloc(2 * sizeof(int));
  if (data == NULL) {
    return -1;  /* Report error  */
  }
  data[0] = 0;
  data[1] = 1;

  if (thrd_success != tss_set(key, (void *)data)) {
    /* Handle error */
  }
  return 0;
}

void print_data(void) {
  /* Get this thread's global data from key */
  int *data = tss_get(key);

  if (data != NULL) {
    /* Print data */
  }
}
```

```
int func(void *dummy) {
  if (add_data() != 0) {
    return -1;  /* Report error */
  }
  print_data();
  return 0;
}

int main(void) {
  thrd_t thread_id[MAX_THREADS];

  /* Create the key before creating the threads */
  if (thrd_success != tss_create(&key, NULL)) {
    /* Handle error */
  }

  /* Create threads that would store specific storage */
  for (size_t i = 0; i < MAX_THREADS; i++) {
    if (thrd_success != thrd_create(&thread_id[i], func, NULL)) {
      /* Handle error */
    }
  }

  for (size_t i = 0; i < MAX_THREADS; i++) {
    if (thrd_success != thrd_join(thread_id[i], NULL)) {
      /* Handle error */
    }
  }

  tss_delete(key);
  return 0;
}
```

In this example, the start function of each thread `func` calls two functions:

- `add_data`: This function allocates storage dynamically and associates the storage with a key using the `tss_set` function.
- `print_data`: This function reads the stored data using the `tss_get` function.

At the points where `func` returns, the dynamically allocated storage has not been freed.

Correction — Free Dynamically Allocated Memory Explicitly

One possible correction is to free dynamically allocated memory explicitly before leaving the start function of a thread. See the highlighted change in the corrected version.

In this corrected version, a defect still appears on the `return` statement in the error handling section of `func`. The defect cannot occur in practice because the error handling section is entered only if dynamic memory allocation fails. Ignore this remaining defect with appropriate comments. See “Address Polyspace Results Through Bug Fixes or Comments”.

```
#include <threads.h>
#include <stdlib.h>

/* Global key to the thread-specific storage */
tss_t key;
enum { MAX_THREADS = 3 };


int add_data(void) {
  int *data = (int *)malloc(2 * sizeof(int));
  if (data == NULL) {
    return -1;  /* Report error  */
  }
  data[0] = 0;
  data[1] = 1;

  if (thrd_success != tss_set(key, (void *)data)) {
    /* Handle error */
  }
  return 0;
}

void print_data(void) {
  /* Get this thread's global data from key */
  int *data = tss_get(key);

  if (data != NULL) {
    /* Print data */
  }
}

int func(void *dummy) {
  if (add_data() != 0) {
```

```
    return -1;  /* Report error */
  }
  print_data();
  free(tss_get(key));
  return 0;
}

int main(void) {
  thrd_t thread_id[MAX_THREADS];

  /* Create the key before creating the threads */
  if (thrd_success != tss_create(&key, NULL)) {
    /* Handle error */
  }

  /* Create threads that would store specific storage */
  for (size_t i = 0; i < MAX_THREADS; i++) {
    if (thrd_success != thrd_create(&thread_id[i], func, NULL)) {
      /* Handle error */
    }
  }

  for (size_t i = 0; i < MAX_THREADS; i++) {
    if (thrd_success != thrd_join(thread_id[i], NULL)) {
      /* Handle error */
    }
  }

  tss_delete(key);
  return 0;
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [filecpy]

Copying a FILE object

Description

Rule Definition

Copying a FILE object.

Examples

Dereferencing a FILE* pointer

Description

The issue occurs when a pointer to a FILE object is dereferenced.

Risk

The Standard states that the address of a FILE object used to control a stream can be significant. Copying that object might not give the same behavior. This rule ensures that you cannot perform such a copy.

Directly manipulating a FILE object might be incompatible with its use as a stream designator.

Example - FILE* Pointer Dereferenced

```
#include <stdio.h>

void func(void) {
    FILE *pf1;
    FILE *pf2;
    FILE f3;

    pf2 = pf1;        /* Compliant */
```

```
    f3 = *pf2;        /* Non-compliant */
    pf2->_flags=0;    /* Non-compliant */
 }
```

In this example, the rule is violated when the `FILE*` pointer `pf2` is dereferenced.

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [funcdecl]

Declaring the same function or object in incompatible ways

Description

Rule Definition

Declaring the same function or object in incompatible ways.

Examples

Indistinguishable external identifier names

Description

The issue occurs when external identifiers are not distinct.

Risk

External identifiers are ones declared with global scope or storage class `extern`.

Polyspace considers two names as distinct if there is a difference between their first 31 characters. If the difference between two names occurs only beyond the first 31 characters, they can be easily mistaken for each other. The readability of the code is reduced. For C90, the difference must occur between the first 6 characters. To use the C90 rules checking, use the value `c90` for the option `C standard version (-c-version)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Example - C90: First Six Characters of Identifiers Not Unique

```
int engine_temperature_raw;
int engine_temperature_scaled;   /* Non-compliant */
int engin2_temperature;          /* Compliant */
```

In this example, the identifier `engine_temperature_scaled` has the same first six characters as a previous identifier, `engine_temperature_raw`.

Example - C99: First 31 Characters of Identifiers Not Unique

```
int engine_exhaust_gas_temperature_raw;
int engine_exhaust_gas_temperature_scaled; /* Non-compliant */

int eng_exhaust_gas_temp_raw;
int eng_exhaust_gas_temp_scaled;           /* Compliant */
```

In this example, the identifier `engine_exhaust_gas_temperature_scaled` has the same first 31 characters as a previous identifier, `engine_exhaust_gas_temperature_raw`.

Example - C90: First Six Characters Identifiers in Different Translation Units Differ in Case Alone

```
/* file1.c */
int abc = 0;

/* file2.c */
int ABC = 0; /* Non-compliant */
```

In this example, the implementation supports 6 significant case-insensitive characters in *external identifiers*. The identifiers in the two translation are different but are not distinct in their significant characters.

Declaration mismatch

Description

Declaration mismatch occurs when a function or variable declaration does not match other instances of the function or variable.

Risk

When a mismatch occurs between two variable declarations in different compilation units, a typical linker follows an algorithm to pick one declaration for the variable. If you expect a variable declaration that is different from the one chosen by the linker, you can see unexpected results when the variable is used.

A similar issue can occur with mismatch in function declarations.

Fix

The fix depends on the type of declaration mismatch. If both declarations indeed refer to the same object, use the same declaration. If the declarations refer to different objects, change the names of the one of the variables. If you change a variable name, remember to make the change in all places that use the variable.

Sometimes, declaration mismatches can occur because the declarations are affected by previous preprocessing directives. For instance, a declaration occurs in a macro, and the macro is defined on one inclusion path but undefined in another. These declaration mismatches can be tricky to debug. Identify the divergence between the two inclusion paths and fix the conflicting macro definitions.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Inconsistent Declarations in Two Files

file1.c

```
int foo(void) {
    return 1;
}
```

file2.c

```
double foo(void);

int bar(void) {
    return (int)foo();
}
```

In this example, *file1.c* declares `foo()` as returning an integer. In *file2.c*, `foo()` is declared as returning a double. This difference raises a defect on the second instance of `foo` in *file2*.

Correction — Align the Function Return Values

One possible correction is to change the function declarations so that they match. In this example, by changing the declaration of `foo` in *file2.c* to match *file1.c*, the defect is fixed.

file1.c

```
int foo(void) {
    return 1;
}
```

file2.c

```
int foo(void);

int bar(void) {
    return foo();
}
```

Example - Inconsistent Structure Alignment

test1.c	*test2.c*

`#include "square.h"`
`#include "circle.h"`
`struct aCircle circle;`
`struct aSquare square;`
 	
`int main(){`
`  square.side=1;`
`  circle.radius=1;`
`  return 0;`
`}`
	`#include "circle.h"`
	`#include "square.h"`
	`struct aCircle circle;`
	`struct aSquare square;`
	
	`int main(){`
	`  square.side=1;`
	`  circle.radius=1;`
	`  return 0;`
	`}`

circle.h
 	
`#pragma pack(1)`
 	
`extern struct aCircle{`
`  int radius;`
`} circle;`
	square.h
	
	`extern struct aSquare {`
	`  unsigned int side:1;`
	`} square;`

In this example, a declaration mismatch defect is raised on `square` in *square.h* because Polyspace infers that `square` in *square.h* does not have the same alignment as `square` in *test2.c*. This error occurs because the `#pragma pack(1)` statement in *circle.h* declares specific alignment. In *test2.c*, *circle.h* is included before *square.h*. Therefore, the `#pragma pack(1)` statement from *circle.h* is not reset to the default alignment after the `aCircle` structure. Because of this omission, *test2.c* infers that the `aSquare square` structure also has an alignment of `1` byte.

Correction — Close Packing Statements

One possible correction is to reset the structure alignment after the `aCircle` struct declaration. For the GNU or Microsoft Visual compilers, fix the defect by adding a `#pragma pack()` statement at the end of *circle.h*.

test1.c

```
#include "square.h"
#include "circle.h"
struct aCircle circle;
struct aSquare square;

int main(){
    square.side=1;
    circle.radius=1;
    return 0;
}
```

test2.c

```
#include "circle.h"
#include "square.h"
struct aCircle circle;
struct aSquare square;

int main(){
    square.side=1;
    circle.radius=1;
    return 0;
}
```

circle.h

```
#pragma pack(1)

extern struct aCircle{
    int radius;
} circle;

#pragma pack()
```

square.h

```
extern struct aSquare {
    unsigned int side:1;
} square;
```

Other compilers require different `#pragma pack` syntax. For your syntax, see the documentation for your compiler.

Correction — Use the `Ignore pragma pack directives` Option

One possible correction is to add the `Ignore pragma pack directives` option to your Bug Finder analysis. If you want the structure alignment to change for each structure, and you do not want to see this **Declaration mismatch** defect, use this correction.

1. On the Configuration pane, select the **Advanced Settings** pane.
2. In the **Other** box, enter `-ignore-pragma-pack`.
3. Rerun your analysis.

   The **Declaration mismatch** defect is resolved.

Check Information

Decidability: Decidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [insufmem]

Allocating insufficient memory

Description

Rule Definition

Allocating insufficient memory.

Examples

Wrong allocated object size for cast

Description

Wrong allocated object size for cast occurs during pointer conversion when the pointer's address is misaligned. If a pointer is converted to a different pointer type, the size of the allocated memory must be a multiple of the size of the destination pointer.

Risk

Dereferencing a misaligned pointer has undefined behavior and can cause your program to crash.

Fix

Suppose you convert a pointer `ptr1` to `ptr2`. If `ptr1` points to a buffer of `N` bytes and `ptr2` is a *`type`* `*` pointer where `sizeof(`*`type`*`)` is `n` bytes, make sure that `N` is an integer multiple of `n`.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See "Address Polyspace Results Through Bug Fixes or Comments".

Example - Dynamic Allocation of Pointers

```
#include <stdlib.h>

void dyn_non_align(void){
    void *ptr = malloc(13);
    long *dest;

    dest = (long*)ptr; //defect
}
```

In this example, the software raises a defect on the conversion of `ptr` to a `long*`. The dynamically allocated memory of `ptr`, 13 bytes, is not a multiple of the size of `dest`, 4 bytes. This misalignment causes the **Wrong allocated object size for cast** defect.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the allocated memory to 12 instead of 13.

```
#include <stdlib.h>

void dyn_non_align(void){
    void *ptr = malloc(12);
    long *dest;

    dest = (long*)ptr;
}
```

Example - Static Allocation of Pointers

```
void static_non_align(void){
    char arr[13], *ptr;
    int *dest;

    ptr = &arr[0];
    dest = (int*)ptr; //defect
}
```

In this example, the software raises a defect on the conversion of `ptr` to an `int*` in line 6. `ptr` has a memory size of 13 bytes because the array `arr` has a size of 13 bytes. The size of `dest` is 4 bytes, which is not a multiple of 13. This misalignment causes the **Wrong allocated object size for cast** defect.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the size of the array `arr` to a multiple of 4.

```
void static_non_align(void){
    char arr[12], *ptr;
    int *dest;

    ptr = &arr[0];
    dest = (int*)ptr;
}
```

Example - Allocation with a Function

```
#include <stdlib.h>

void *my_alloc(int size) {
    void *ptr_func = malloc(size);
    if(ptr_func == NULL) exit(-1);
    return ptr_func;
}

void fun_non_align(void){
    int *dest1;
    char *dest2;

    dest1 = (int*)my_alloc(13);  //defect
    dest2 = (char*)my_alloc(13); //not a defect
}
```

In this example, the software raises a defect on the conversion of the pointer returned by `my_alloc(13)` to an `int*` in line 11. `my_alloc(13)` returns a pointer with a dynamically allocated size of 13 bytes. The size of `dest1` is 4 bytes, which is not a divisor of 13. This misalignment causes the **Wrong allocated object size for cast** defect. In line 12, the same function call, `my_alloc(13)`, does not call a defect for the conversion to `dest2` because the size of `char*`, 1 byte, a divisor of 13.

Correction — Change the Size of the Pointer

One possible correction is to use a pointer size that is a multiple of the destination size. In this example, resolve the defect by changing the argument for `my_alloc` to a multiple of 4.

```
#include <stdlib.h>

void *my_alloc(int size) {
    void *ptr_func = malloc(size);
    if(ptr_func == NULL) exit(-1);
    return ptr_func;
}

void fun_non_align(void){
    int *dest1;
    char *dest2;

    dest1 = (int*)my_alloc(12);
    dest2 = (char*)my_alloc(13);
}
```

Pointer access out of bounds

Description

Pointer access out of bounds occurs when a pointer is dereferenced outside its bounds.

When a pointer is assigned an address, a block of memory is associated with the pointer. You cannot access memory beyond that block using the pointer.

Risk

Dereferencing a pointer outside its bounds is undefined behavior. You can read an unpredictable value or try to access a location that is not allowed and encounter a segmentation fault.

Fix

The fix depends on the root cause of the defect. For instance, you dereferenced a pointer inside a loop and one of these situations happened:

- The upper bound of the loop is too large.
- You used pointer arithmetic to advance the pointer with an incorrect value for the pointer increment.

To fix the issue, you have to modify the loop bound or the pointer increment value.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event

history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Pointer access out of bounds error

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
   {
    ptr++;
    *ptr=i;
    /* Defect: ptr out of bounds for i=9 */
   }

 return(arr);
}
```

`ptr` is assigned the address `arr` that points to a memory block of size `10*sizeof(int)`. In the `for`-loop, `ptr` is incremented 10 times. In the last iteration of the loop, `ptr` points outside the memory block assigned to it. Therefore, it cannot be dereferenced.

Correction — Check Pointer Stays Within Bounds

One possible correction is to reverse the order of increment and dereference of `ptr`.

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
     {
      /* Fix: Dereference pointer before increment */
      *ptr=i;
      ptr++;
     }
```

```
 return(arr);
}
```

After the last increment, even though `ptr` points outside the memory block assigned to it, it is not dereferenced more.

Wrong type used in sizeof

Description

Wrong type used in sizeof occurs when both of the following conditions hold:

- You assign the address of a block of memory to a pointer, or transfer data between two blocks of memory. The assignment or copy uses the `sizeof` operator.

  For instance, you initialize a pointer using `malloc(sizeof(`*`type`*`))` or copy data between two addresses using `memcpy(`*`destination_ptr`*`, `*`source_ptr`*`, sizeof(`*`type`*`))`.
- You use an incorrect type as argument of the `sizeof` operator. You use the pointer type instead of the type that the pointer points to.

  For instance, to initialize a *`type`*`*` pointer, you use `malloc(sizeof(`*`type`*`*))` instead of `malloc(sizeof(`*`type`*`))`.

Risk

Irrespective of what *`type`* stands for, the expression `sizeof(`*`type`*`*)` always returns a fixed size. The size returned is the pointer size on your platform in bytes. The appearance of `sizeof(`*`type`*`*)` often indicates an unintended usage. The error can cause allocation of a memory block that is much smaller than what you need and lead to weaknesses such as buffer overflows.

For instance, assume that `structType` is a structure with ten `int` variables. If you initialize a `structType*` pointer using `malloc(sizeof(structType*))` on a 32-bit platform, the pointer is assigned a memory block of four bytes. However, to be allocated completely for one `structType` variable, the `structType*` pointer must point to a memory block of `sizeof(structType) = 10 * sizeof(int)` bytes. The required size is much greater than the actual allocated size of four bytes.

Fix

To initialize a *type** pointer, replace `sizeof(`*type*`*)` in your pointer initialization expression with `sizeof(`*type*`)`.

Example - Allocate a Char Array With `sizeof`

```
#include <stdlib.h>

void test_case_1(void) {
    char* str;

    str = (char*)malloc(sizeof(char*) * 5);
    free(str);

}
```

In this example, memory is allocated for the character pointer `str` using a `malloc` of five char pointers. However, `str` is a pointer to a character, not a pointer to a character pointer. Therefore the `sizeof` argument, `char*`, is incorrect.

Correction — Match Pointer Type to `sizeof` Argument

One possible correction is to match the argument to the pointer type. In this example, `str` is a character pointer, therefore the argument must also be a character.

```
#include <stdlib.h>

void test_case_1(void) {
    char* str;

    str = (char*)malloc(sizeof(char) * 5);
    free(str);

}
```

Possible misuse of sizeof

Description

Possible misuse of sizeof occurs when Polyspace Bug Finder detects possibly unintended results from the use of `sizeof` operator. For instance:

- You use the `sizeof` operator on an array parameter name, expecting the array size. However, the array parameter name by itself is a pointer. The `sizeof` operator returns the size of that pointer.
- You use the `sizeof` operator on an array element, expecting the array size. However, the operator returns the size of the array element.
- The size argument of certain functions such as `strncmp` or `wcsncpy` is incorrect because you used the `sizeof` operator earlier with possibly incorrect expectations. For instance:
  - In a function call `strncmp(string1, string2, num)`, `num` is obtained from an incorrect use of the `sizeof` operator on a pointer.
  - In a function call `wcsncpy(destination, source, num)`, `num` is the not the number of wide characters but a size in bytes obtained by using the `sizeof` operator. For instance, you use `wcsncpy(destination, source, sizeof(destination) - 1)` instead of `wcsncpy(destination, source, (sizeof(desintation)/sizeof(wchar_t)) - 1)`.

Risk

Incorrect use of the `sizeof` operator can cause the following issues:

- If you expect the `sizeof` operator to return array size and use the return value to constrain a loop, the number of loop runs are smaller than what you expect.
- If you use the return value of `sizeof` operator to allocate a buffer, the buffer size is smaller than what you require. Insufficient buffer can lead to resultant weaknesses such as buffer overflows.
- If you use the return value of `sizeof` operator incorrectly in a function call, the function does not behave as you expect.

Fix

Possible fixes are:

- Do not use the `sizeof` operator on an array parameter name or array element to determine array size.

  The best practice is to pass the array size as a separate function parameter and use that parameter in the function body.
- Use the `sizeof` operator carefully to determine the number argument of functions such as `strncmp` or `wcsncpy`. For instance, for wide string functions such as

`wcsncpy`, use the number of wide characters as argument instead of the number of bytes.

Example - `sizeof` Used Incorrectly to Determine Array Size

```
#define MAX_SIZE 1024

void func(int a[MAX_SIZE]) {
    int i;

    for (i = 0; i < sizeof(a)/sizeof(int); i++)    {
        a[i] = i + 1;
    }
}
```

In this example, `sizeof(a)` returns the size of the pointer `a` and not the array size.

Correction — Determine Array Size in Another Way

One possible correction is to use another means to determine the array size.

```
#define MAX_SIZE 1024

void func(int a[MAX_SIZE]) {
    int i;

    for (i = 0; i < MAX_SIZE; i++)    {
        a[i] = i + 1;
    }
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [intoflow]

Overflowing signed integers

Description

Rule Definition

Overflowing signed integers.

Examples

Integer overflow

Description

Integer overflow occurs when an operation on integer variables can result in values that cannot be represented by the result data type. The data type of a variable determines the number of bytes allocated for the variable storage and constrains the range of allowed values.

The exact storage allocation for different integer types depends on your processor. See `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

Integer overflows on signed integers result in undefined behavior.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. Use this event list to determine how the variables in the overflowing computation acquire their current values. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace

back using right-click options in the source code and see previous related events. See also “Interpret Polyspace Bug Finder Access Results”.

You can fix the defect by:

- Using a bigger data type for the result of the operation so that all values can be accommodated.
- Checking for values that lead to the overflow and performing appropriate error handling.

To avoid overflows in general, try one of these techniques:

- Keep integer variable values restricted to within half the range of signed integers.
- In operations that might overflow, check for conditions that can lead to the overflow and implement wrap around or saturation behavior depending on how the result of the operation is used. The result then becomes predictable and can be safely used in subsequent computations.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Addition of Maximum Integer

```
#include <limits.h>

int plusplus(void) {

    int var = INT_MAX;
    var++;
    return var;
}
```

In the third statement of this function, the variable `var` is increased by one. But the value of `var` is the maximum integer value, so an `int` cannot represent one plus the maximum integer value.

Correction — Different Storage Type

One possible correction is to change data types. Store the result of the operation in a larger data type (Note that on a 32-bit machine, `int` and `long` has the same size). In this

example, on a 32-bit machine, by returning a `long long` instead of an `int`, the overflow error is fixed.

```
#include <limits.h>

long long plusplus(void) {

    long long lvar = INT_MAX;
    lvar++;
    return lvar;
}
```

Integer constant overflow

Description

Integer constant overflow occurs when you assign a compile-time constant to a signed integer variable whose data type cannot accommodate the value. An `n`-bit signed integer holds values in the range $[-2^{n-1}, 2^{n-1}-1]$.

For instance, `c` is an 8-bit signed `char` variable that cannot hold the value 255.

```
signed char c = 255;
```

To determine the sizes of fundamental types, Bug Finder uses your specification for `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Risk

The default behavior for constant overflows can vary between compilers and platforms. Retaining constant overflows can reduce the portability of your code.

Even if your compilers wraps around overflowing constants with a warning, the wrap-around behavior can be unintended and cause unexpected results.

Fix

Check if the constant value is what you intended. If the value is correct, use a different, possibly wider, data type for the variable.

Example - Overflowing Constant from Macro Expansion

```
#define MAX_UNSIGNED_CHAR 255
#define MAX_SIGNED_CHAR 127

void main() {
    char c1 = MAX_UNSIGNED_CHAR;
    char c2 = MAX_SIGNED_CHAR+1;
}
```

In this example, the defect appears on the macros because at least one use of the macro causes an overflow. To reproduce these defects, use analysis option `Target processor type (-target)` where `char` is signed by default. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Correction — Use Different Data Type

One possible correction is to use a different data type for the variables that overflow.

```
#define MAX_UNSIGNED_CHAR 255
#define MAX_SIGNED_CHAR 127

void main() {
    unsigned char c1 = MAX_UNSIGNED_CHAR;
    unsigned char c2 = MAX_SIGNED_CHAR+1;
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [intptrconv]

Converting a pointer to integer or integer to pointer

Description

Rule Definition

Converting a pointer to integer or integer to pointer.

Examples

Conversion between pointers and integers

Description

The issue occurs when a conversion is performed between a pointer to object and an integer type.

Casts or implicit conversions from `NULL` or `(void*)0` do not generate a warning.

Risk

Conversion between integers and pointers can cause errors or undefined behavior.

- If an integer is cast to a pointer, the resulting pointer can be incorrectly aligned. The incorrect alignment causes undefined behavior.
- If a pointer is cast to an integer, the resulting value can be outside the allowed range for the integer type.

Example - Casts between pointer and integer

```
#include <stdbool.h>

typedef unsigned char      uint8_t;
typedef          char      char_t;
```

```
typedef unsigned short     uint16_t;
typedef signed   int       int32_t;

typedef _Bool bool_t;
uint8_t *PORTA = (uint8_t *) 0x0002;            /* Non-compliant */

void foo(void) {

    char_t c = 1;
    char_t *pc = &c;                              /* Compliant */


    uint16_t ui16   = 7U;
    uint16_t *pui16 = &ui16;                      /* Compliant */
    pui16 = (uint16_t *) ui16;                    /* Non-compliant */


    uint16_t *p;
    int32_t addr = (int32_t) p;                  /* Non-compliant */
    bool_t b = (bool_t) p;                       /* Non-compliant */
    enum etag { A, B } e = ( enum etag ) p;      /* Non-compliant */
}
```

In this example, the rule is violated when:

- The integer `0x0002` is cast to a pointer.

  If the integer defines an absolute address, it is more common to assign the address to a pointer in a header file. To avoid the assignment being flagged, you can then exclude headers files from coding rules checking. For more information, see `Do not generate results for (-do-not-generate-results-for)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.
- The pointer `p` is cast to integer types such as `int32_t`, `bool_t` or `enum etag`.

The rule is not violated when the address `&ui16` is assigned to a pointer.

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [inverrno]

Incorrectly setting and using errno

Description

Rule Definition

Incorrectly setting and using errno.

Examples

Misuse of errno

Description

Misuse of errno occurs when you check `errno` for error conditions in situations where checking `errno` does not guarantee the absence of errors. In some cases, checking `errno` can lead to false positives.

For instance, you check `errno` following calls to the functions:

- `fopen`: If you follow the ISO Standard, the function might not set `errno` on errors.
- `atof`: If you follow the ISO Standard, the function does not set `errno`.
- `signal`: The `errno` value indicates an error only if the function returns the `SIG_ERR` error indicator.

Risk

The ISO C Standard does not enforce that these functions set `errno` on errors. Whether the functions set `errno` or not is implementation-dependent.

To detect errors, if you check `errno` alone, the validity of this check also becomes implementation-dependent.

In some cases, the `errno` value indicates an error only if the function returns a specific error indicator. If you check `errno` before checking the function return value, you can see false positives.

Fix

For information on how to detect errors, see the documentation for that specific function.

Typically, the functions return an out-of-band error indicator to indicate errors. For instance:

- `fopen` returns a null pointer if an error occurs.
- `signal` returns the `SIG_ERR` error indicator and sets `errno` to a positive value. Check `errno` only after you have checked the function return value.

Example - Incorrectly Checking for `errno` After `fopen` Call

```
#include <stdio.h>
#include <stdlib.h>
#include <errno.h>

#define fatal_error() abort()

const char *temp_filename = "/tmp/demo.txt";

FILE *func()
{
    FILE *fileptr;
    errno = 0;
    fileptr = fopen(temp_filename, "w+b");
    if (errno != 0) {
        if (fileptr != NULL) {
            (void)fclose(fileptr);
        }
        /* Handle error */
        fatal_error();
    }
    return fileptr;
}
```

In this example, `errno` is the first variable that is checked after a call to `fopen`. You might expect that `fopen` changes `errno` to a nonzero value if an error occurs. If you run this code with an implementation of `fopen` that does not set `errno` on errors, you might

miss an error condition. In this situation, `fopen` can return a null pointer that escapes detection.

Correction — Check Return Value of `fopen` After Call

One possible correction is to only check the return value of `fopen` for a null pointer.

```
#include <stdio.h>
#include <stdlib.h>
#include <errno.h>

#define fatal_error() abort()

const char *temp_filename = "/tmp/demo.txt";

FILE *func()
{
    FILE *fileptr;
    fileptr = fopen(temp_filename, "w+b");
    if (fileptr == NULL) {
        fatal_error();
    }
    return fileptr;
}
```

Errno not checked

Description

Errno not checked occurs when you call a function that sets `errno` to indicate error conditions, but do not check `errno` after the call. For these functions, checking `errno` is the only reliable way to determine if an error occurred.

Functions that set `errno` on errors include:

- `fgetwc`, `strtol`, and `wcstol`.

  For a comprehensive list of functions, see documentation about errno.
- POSIX `errno`-setting functions such as `encrypt` and `setkey`.

Risk

To see if the function call completed without errors, check `errno` for error values.

The return values of these `errno`-setting functions do not indicate errors. The return value can be one of the following:

- `void`
- Even if an error occurs, the return value can be the same as the value from a successful call. Such return values are called in-band error indicators.

You can determine if an error occurred only by checking `errno`.

For instance, `strtol` converts a string to a long integer and returns the integer. If the result of conversion overflows, the function returns `LONG_MAX` and sets `errno` to `ERANGE`. However, the function can also return `LONG_MAX` from a successful conversion. Only by checking `errno` can you distinguish between an error and a successful conversion.

Fix

Before calling the function, set `errno` to zero.

After the function call, to see if an error occurred, compare `errno` to zero. Alternatively, compare `errno` to known error indicator values. For instance, `strtol` sets `errno` to `ERANGE` to indicate errors.

The error message in the Polyspace result shows the error indicator value that you can compare to.

Example - `errno` Not Checked After Call to `strtol`

```
#include<stdio.h>
#include<stdlib.h>
#include<errno.h>

int main(int argc, char *argv[]) {
    char *str, *endptr;
    int base;

    str = argv[1];
    base = 10;

    long val = strtol(str, &endptr, base);
    printf("Return value of strtol() = %ld\n", val);
}
```

You are using the return value of `strtol` without checking `errno`.

Correction — Check `errno` After Call

Before calling `strtol`, set `errno` to zero . After a call to `strtol`, check the return value for `LONG_MIN` or `LONG_MAX` and `errno` for `ERANGE`.

```
#include<stdlib.h>
#include<stdio.h>
#include<errno.h>
#include<limits.h>

int main(int argc, char *argv[]) {
    char *str, *endptr;
    int base;

    str = argv[1];
    base = 10;

    errno = 0;
    long val = strtol(str, &endptr, base);
    if((val == LONG_MIN || val == LONG_MAX) && errno == ERANGE) {
         printf("strtol error");
         exit(EXIT_FAILURE);
    }
    printf("Return value of strtol() = %ld\n", val);
}
```

Errno not reset

Description

Errno not reset occurs when you do not reset `errno` before calling a function that sets `errno` to indicate error conditions. However, you check `errno` for those error conditions after the function call.

Risk

The `errno` is not clean and can contain values from a previous call. Checking `errno` for errors can give the false impression that an error occurred.

`errno` is set to zero at program startup but subsequently, `errno` is not reset by a C standard library function. You must explicitly set `errno` to zero when required.

Fix

Before calling a function that sets `errno` to indicate error conditions, reset `errno` to zero explicitly.

Example - `errno` Not Reset Before Call to `strtod`

```
#include <stdio.h>
#include <stdlib.h>
#include <errno.h>
#include <float.h>

#define fatal_error() abort()

double func(const char *s1, const char *s2)
{
    double f1;
    f1 = strtod (s1, NULL);
    if (0 == errno) {
      double f2 = strtod (s2, NULL);
        if (0 == errno) {
            long double result = (long double)f1 + f2;
            if ((result <= (long double)DBL_MAX) && (result >= (long double)-DBL_MAX))
                  {
                return (double)result;
            }
        }
    }
    fatal_error();
    return 0.0;
}
```

In this example, `errno` is not reset to 0 before the first call to `strtod`. Checking `errno` for 0 later can lead to a false positive.

Correction — Reset `errno` Before Call

One possible correction is to reset `errno` to 0 before calling `strtod`.

```
#include <stdio.h>
#include <stdlib.h>
#include <errno.h>
#include <float.h>
```

```
#define fatal_error() abort()

double func(const char *s1, const char *s2)
{
    double f1;
    errno = 0;
    f1 = strtod (s1, NULL);
    if (0 == errno) {
      double f2 = strtod (s2, NULL);
        if (0 == errno) {
            long double result = (long double)f1 + f2;
            if ((result <= (long double)DBL_MAX) && (result >= (long double)-DBL_MAX))
              {
                return (double)result;
            }
        }
    }
    fatal_error();
    return 0.0;
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [invfmtstr]

Using invalid format strings

Description

Rule Definition

Using invalid format strings.

Examples

Format string specifiers and arguments mismatch

Description

Format string specifiers and arguments mismatch occurs when the format specifiers in the formatted output functions such as `printf` do not match their corresponding arguments. For example, an argument of type `unsigned long` must have a format specification of `%lu`.

Risk

Mismatch between format specifiers and the corresponding arguments result in undefined behavior.

Fix

Make sure that the format specifiers match the corresponding arguments. For instance, in this example, the `%d` specifier does not match the string argument `message` and the `%s` specifier does not match the integer argument `err_number`.

```
const char *message = "License not available";
int err_number = ;-4
printf("Error: %d (error type %s)\n", message, err_number);
```

Switching the two format specifiers fixes the issue. See the specifications for the printf function for more information about format specifiers.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Printing a Float

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;

    printf("%d\n", fst);
}
```

In the `printf` statement, the format specifier, `%d`, does not match the data type of `fst`.

Correction — Use an Unsigned Long Format Specifier

One possible correction is to use the `%lu` format specifier. This specifier matches the `unsigned` integer type and `long` size of `fst`.

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;

    printf("%lu\n", fst);
}
```

Correction — Use an Integer Argument

One possible correction is to change the argument to match the format specifier. Convert `fst` to an integer to match the format specifier and print the value `1`.

```
#include <stdio.h>

void string_format(void) {

    unsigned long fst = 1;
```

```
    printf("%d\n", (int)fst);
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [invptr]

Forming or using out-ofbounds pointers or array subscripts

Description

Rule Definition

Forming or using out-ofbounds pointers or array subscripts.

Examples

Array access out of bounds

Description

Array access out of bounds occurs when an array index falls outside the range `[0...array_size-1]` during array access.

Risk

Accessing an array outside its bounds is undefined behavior. You can read an unpredictable value or try to access a location that is not allowed and encounter a segmentation fault.

Fix

The fix depends on the root cause of the defect. For instance, you accessed an array inside a loop and one of these situations happened:

- The upper bound of the loop is too large.
- You used an array index that is the same as the loop index instead of being one less than the loop index.

To fix the issue, you have to modify the loop bound or the array index.

Another reason why an array index can exceed array bounds is a prior conversion from signed to unsigned integers. The conversion can result in a wrap around of the index value, eventually causing the array index to exceed the array bounds.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Array Access Out of Bounds Error

```
#include <stdio.h>

void fibonacci(void)
{
    int i;
    int fib[10];

    for (i = 0; i < 10; i++)
       {
        if (i < 2)
            fib[i] = 1;
         else
            fib[i] = fib[i-1] + fib[i-2];
       }

    printf("The 10-th Fibonacci number is %i .\n", fib[i]);
    /* Defect: Value of i is greater than allowed value of 9 */
}
```

The array `fib` is assigned a size of 10. An array index for `fib` has allowed values of `[0,1,2,...,9]`. The variable `i` has a value 10 when it comes out of the `for`-loop. Therefore, the `printf` statement attempts to access `fib[10]` through `i`.

Correction — Keep Array Index Within Array Bounds

One possible correction is to print `fib[i-1]` instead of `fib[i]` after the `for`-loop.

```
#include <stdio.h>
```

```
void fibonacci(void)
{
   int i;
   int fib[10];

   for (i = 0; i < 10; i++)
    {
        if (i < 2)
            fib[i] = 1;
        else
            fib[i] = fib[i-1] + fib[i-2];
    }

    /* Fix: Print fib[9] instead of fib[10] */
    printf("The 10-th Fibonacci number is %i .\n", fib[i-1]);
}
```

The `printf` statement accesses `fib[9]` instead of `fib[10]`.

Pointer access out of bounds

Description

Pointer access out of bounds occurs when a pointer is dereferenced outside its bounds.

When a pointer is assigned an address, a block of memory is associated with the pointer. You cannot access memory beyond that block using the pointer.

Risk

Dereferencing a pointer outside its bounds is undefined behavior. You can read an unpredictable value or try to access a location that is not allowed and encounter a segmentation fault.

Fix

The fix depends on the root cause of the defect. For instance, you dereferenced a pointer inside a loop and one of these situations happened:

- The upper bound of the loop is too large.
- You used pointer arithmetic to advance the pointer with an incorrect value for the pointer increment.

To fix the issue, you have to modify the loop bound or the pointer increment value.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Pointer access out of bounds error

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
   {
    ptr++;
    *ptr=i;
    /* Defect: ptr out of bounds for i=9 */
   }

 return(arr);
}
```

`ptr` is assigned the address `arr` that points to a memory block of size `10*sizeof(int)`. In the `for`-loop, `ptr` is incremented 10 times. In the last iteration of the loop, `ptr` points outside the memory block assigned to it. Therefore, it cannot be dereferenced.

Correction — Check Pointer Stays Within Bounds

One possible correction is to reverse the order of increment and dereference of `ptr`.

```
int* Initialize(void)
{
 int arr[10];
 int *ptr=arr;

 for (int i=0; i<=9;i++)
     {
```

```
      /* Fix: Dereference pointer before increment */
      *ptr=i;
      ptr++;
     }

 return(arr);
}
```

After the last increment, even though `ptr` points outside the memory block assigned to it, it is not dereferenced more.

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [ioileave]

Interleaving stream inputs and outputs without a flush or positioning call

Description

Rule Definition

Interleaving stream inputs and outputs without a flush or positioning call.

Examples

Alternating input and output from a stream without flush or positioning call

Description

Alternating input and output from a stream without flush or positioning call occurs when:

- You do not perform a flush or function positioning call between an output operation and a following input operation on a file stream in update mode.
- You do not perform a function positioning call between an input operation and a following output operation on a file stream in update mode.

Risk

Alternating input and output operations on a stream without an intervening flush or positioning call is undefined behavior.

Fix

Call `fflush()` or a file positioning function such as `fseek()` or `fsetpos()` between output and input operations on an update stream.

Call a file positioning function between input and output operations on an update stream.

Example - Read After Write Without Intervening Flush

```
#include <stdio.h>
#define SIZE20 20

void initialize_data(char* data, size_t s) {};
const char *temp_filename = "/tmp/demo.txt";

void func()
{
    char data[SIZE20];
    char append_data[SIZE20];
    FILE *file;

    file = fopen(temp_filename, "a+");
    if (file == NULL)
      {
        /* Handle error. */;
      }

    initialize_data(append_data, SIZE20);

    if (fwrite(append_data, 1, SIZE20, file) != SIZE20)
      {
        (void)fclose(file);
        /* Handle error. */;
      }
    /* Read operation after write without
    intervening flush. */
    if (fread(data, 1, SIZE20, file) < SIZE20)
      {
          (void)fclose(file);
          /* Handle error. */;
      }

    if (fclose(file) == EOF)
      {
        /* Handle error. */;
      }
}
```

In this example, the file `demo.txt` is opened for reading and appending. After the call to `fwrite()`, a call to `fread()` without an intervening flush operation is undefined behavior.

Correction — Call `fflush()` Before the Read Operation

After writing data to the file, before calling `fread()`, perform a flush call.

```
#include <stdio.h>
#define SIZE20 20

void initialize_data(char* data, size_t s) {};
const char *temp_filename = "/tmp/demo.txt";


void func()
{
    char data[SIZE20];
    char append_data[SIZE20];
    FILE *file;

    file = fopen(temp_filename, "a+");
    if (file == NULL)
      {
        /* Handle error. */;
      }

    initialize_data(append_data, SIZE20);

    if (fwrite(append_data, 1, SIZE20, file) != SIZE20)
      {
        (void)fclose(file);
        /* Handle error. */;
      }
    /* Buffer flush after write and before read */
    if (fflush(file) != 0)
      {
        (void)fclose(file);
        /* Handle error. */;
      }
    if (fread(data, 1, SIZE20, file) < SIZE20)
      {
        (void)fclose(file);
        /* Handle error. */;
```

```
      }

    if (fclose(file) == EOF)
      {
        /* Handle error. */;
      }
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [liberr]

Failing to detect and handle standard library errors

Description

Rule Definition

Failing to detect and handle standard library errors.

Examples

Returned value of a sensitive function not checked

Description

Returned value of a sensitive function not checked occurs when you call sensitive standard functions, but you:

- Ignore the return value.
- Use an output or a return value without testing the validity of the return value.

For this defect, two type of functions are considered: ***sensitive*** and ***critical sensitive***.

A ***sensitive*** function is a standard function that can encounter:

- Exhausted system resources (for example, when allocating resources)
- Changed privileges or permissions
- Tainted sources when reading, writing, or converting data from external sources
- Unsupported features despite an existing API

A ***critical sensitive*** function is a sensitive function that performs one of these critical or vulnerable tasks:

- Set privileges (for example, `setuid`)
- Create a jail (for example, `chroot`)
- Create a process (for example, `fork`)
- Create a thread (for example, `pthread_create`)
- Lock or unlock mutex (for example, `pthread_mutex_lock`)
- Lock or unlock memory segments (for example, `mlock`)

Risk

If you do not check the return value of functions that perform sensitive or critical sensitive tasks, your program can behave unexpectedly. Errors from these functions can propagate throughout the program causing incorrect output, security vulnerabilities, and possibly system failures.

Fix

Before continuing with the program, test the return value of *critical sensitive* functions.

For *sensitive functions*, you can explicitly ignore a return value by casting the function to `void`. Polyspace does not raise this defect for sensitive functions cast to void. This resolution is not accepted for *critical sensitive functions* because they perform more vulnerable tasks.

Example - Sensitive Function Return Ignored

```
#include <pthread.h>

void initialize() {
    pthread_attr_t attr;

    pthread_attr_init(&attr);
}
```

This example shows a call to the sensitive function `pthread_attr_init`. The return value of `pthread_attr_init` is ignored, causing a defect.

Correction — Cast Function to `(void)`

One possible correction is to cast the function to void. This fix informs Polyspace and any reviewers that you are explicitly ignoring the return value of the sensitive function.

```
#include <pthread.h>

void initialize() {
    pthread_attr_t attr;

    (void)pthread_attr_init(&attr);
}
```

Correction — Test Return Value

One possible correction is to test the return value of `pthread_attr_init` to check for errors.

```
#include <pthread.h>
#include <stdlib.h>
#define fatal_error() abort()

void initialize() {
    pthread_attr_t attr;
    int result;

    result = pthread_attr_init(&attr);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }
}
```

Example - Critical Function Return Ignored

```
#include <pthread.h>
extern void *start_routine(void *);

void returnnotchecked() {
    pthread_t thread_id;
    pthread_attr_t attr;
    void *res;

    (void)pthread_attr_init(&attr);
    (void)pthread_create(&thread_id, &attr, &start_routine, ((void *)0));
    pthread_join(thread_id,  &res);
}
```

In this example, two critical functions are called: `pthread_create` and `pthread_join`. The return value of the `pthread_create` is ignored by casting to void, but because

`pthread_create` is a critical function (not just a sensitive function), Polyspace does not ignore this *Return value of a sensitive function not checked* defect. The other critical function, `pthread_join`, returns value that is ignored implicitly. `pthread_join` uses the return value of `pthread_create`, which was not checked.

Correction — Test the Return Value of Critical Functions

The correction for this defect is to check the return value of these critical functions to verify the function performed as expected.

```
#include <pthread.h>
#include <stdlib.h>
#define fatal_error() abort()

extern void *start_routine(void *);

void returnnotchecked() {
    pthread_t thread_id;
    pthread_attr_t attr;
    void *res;
    int result;

    (void)pthread_attr_init(&attr);
    result = pthread_create(&thread_id, &attr, &start_routine, NULL);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }

    result = pthread_join(thread_id,  &res);
    if (result != 0) {
        /* Handle error */
        fatal_error();
    }
}
```

Unprotected dynamic memory allocation

Description

Unprotected dynamic memory allocation occurs when you do not check after dynamic memory allocation whether the memory allocation succeeded.

Risk

When memory is dynamically allocated using `malloc`, `calloc`, or `realloc`, it returns a value `NULL` if the requested memory is not available. If the code following the allocation accesses the memory block without checking for this `NULL` value, this access is not protected from failures.

Fix

Check the return value of `malloc`, `calloc`, or `realloc` for NULL before accessing the allocated memory location.

```
int *ptr = malloc(size * sizeof(int));

if(ptr) /* Check for NULL */
{
   /* Memory access through ptr */
}
```

Example - Unprotected dynamic memory allocation error

```
#include <stdlib.h>

void Assign_Value(void)
{
  int* p = (int*)calloc(5, sizeof(int));

  *p = 2;
  /* Defect: p is not checked for NULL value */

  free(p);
}
```

If the memory allocation fails, the function `calloc` returns `NULL` to `p`. Before accessing the memory through `p`, the code does not check whether `p` is `NULL`

Correction — Check for NULL Value

One possible correction is to check whether `p` has value `NULL` before dereference.

```
#include <stdlib.h>

void Assign_Value(void)
 {
```

```
  int* p = (int*)calloc(5, sizeof(int));

  /* Fix: Check if p is NULL */
  if(p!=NULL) *p = 2;

  free(p);
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [libmod]

Modifying the string returned by getenv, localeconv, setlocale, and strerror

Description

Rule Definition

Modifying the string returned by getenv, localeconv, setlocale, and strerror.

Examples

Modification of internal buffer returned from nonreentrant standard function

Description

Modification of internal buffer returned from nonreentrant standard function occurs when the following happens:

- A nonreentrant standard function returns a pointer.
- You attempt to write to the memory location that the pointer points to.

Nonreentrant standard functions that return a non `const`-qualified pointer to an internal buffer include `getenv`, `getlogin`, `crypt`, `setlocale`, `localeconv`, `strerror` and others.

Risk

Modifying the internal buffer that a nonreentrant standard function returns can cause the following issues:

- It is possible that the modification does not succeed or alters other internal data.

  For instance, `getenv` returns a pointer to an environment variable value. If you modify this value, you alter the environment of the process and corrupt other internal data.

- Even if the modification succeeds, it is possible that a subsequent call to the same standard function does not return your modified value.

  For instance, you modify the environment variable value that `getenv` returns. If another process, thread, or signal handler calls `setenv`, the modified value is overwritten. Therefore, a subsequent call to `getenv` does not return your modified value.

Fix

Avoid modifying the internal buffer using the pointer returned from the function.

Example - Modification of `getenv` Return Value

```
#include <stdlib.h>
#include <string.h>

void printstr(const char*);

void func() {
    char* env = getenv("LANGUAGE");
    if (env != NULL) {
        strncpy(env, "C", 1);
        printstr(env);
    }
}
```

In this example, the first argument of `strncpy` is the return value from a nonreentrant standard function `getenv`. The behavior can be undefined because `strncpy` modifies this argument.

Correction - Copy Return Value of `getenv` and Modify Copy

One possible solution is to copy the return value of `getenv` and pass the copy to the `strncpy` function.

```
#include <stdlib.h>
#include <string.h>
enum {
    SIZE20 = 20
};

void printstr(const char*);
```

```
void func() {
    char* env = getenv("LANGUAGE");
    if (env != NULL) {
        char env_cp[SIZE20];
        strncpy(env_cp, env, SIZE20);
        strncpy(env_cp, "C", 1);
        printstr(env_cp);
    }
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [libptr]

Forming invalid pointers by library function

Description

Rule Definition

Forming invalid pointers by library function.

Examples

Use of path manipulation function without maximum sized buffer checking

Description

Use of path manipulation function without maximum-sized buffer checking occurs when the destination argument of a path manipulation function such as `realpath` or `getwd` has a buffer size less than `PATH_MAX` bytes.

Risk

A buffer smaller than `PATH_MAX` bytes can overflow but you cannot test the function return value to determine if an overflow occurred. If an overflow occurs, following the function call, the content of the buffer is undefined.

For instance, `char *getwd(char *buf)` copies an absolute path name of the current folder to its argument. If the length of the absolute path name is greater than `PATH_MAX` bytes, `getwd` returns `NULL` and the content of `*buf` is undefined. You can test the return value of `getwd` for `NULL` to see if the function call succeeded.

However, if the allowed buffer for `buf` is less than `PATH_MAX` bytes, a failure can occur for a smaller absolute path name. In this case, `getwd` does not return `NULL` even though a failure occurred. Therefore, the allowed buffer for `buf` must be `PATH_MAX` bytes long.

Fix

Possible fixes are:

- Use a buffer size of PATH_MAX bytes. If you obtain the buffer from an unknown source, before using the buffer as argument of `getwd` or `realpath` function, make sure that the size is less than PATH_MAX bytes.
- Use a path manipulation function that allows you to specify a buffer size.

  For instance, if you are using `getwd` to get the absolute path name of the current folder, use `char *getcwd(char *buf, size_t size);` instead. The additional argument `size` allows you to specify a size greater than or equal to PATH_MAX.
- Allow the function to allocate additional memory dynamically, if possible.

  For instance, `char *realpath(const char *path, char *resolved_path);` dynamically allocates memory if `resolved_path` is NULL. However, you have to deallocate this memory later using the `free` function.

Example - Possible Buffer Overflow in Use of `getwd` Function

```
#include <unistd.h>
#include <linux/limits.h>
#include <stdio.h>

void func(void) {
    char buf[PATH_MAX];
    if (getwd(buf+1)!= NULL)         {
        printf("cwd is %s\n", buf);
    }
}
```

In this example, although the array `buf` has PATH_MAX bytes, the argument of `getwd` is `buf + 1`, whose allowed buffer is less than PATH_MAX bytes.

Correction — Use Array of Size PATH_MAX Bytes

One possible correction is to use an array argument with size equal to PATH_MAX bytes.

```
#include <unistd.h>
#include <linux/limits.h>
#include <stdio.h>

void func(void) {
```

```
    char buf[PATH_MAX];
    if (getwd(buf)!= NULL)         {
        printf("cwd is %s\n", buf);
    }
}
```

Invalid use of standard library memory routine

Description

Invalid use of standard library memory routine occurs when a memory library function is called with invalid arguments. For instance, the `memcpy` function copies to an array that cannot accommodate the number of bytes copied.

Risk

Use of a memory library function with invalid arguments can result in issues such as buffer overflow.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Invalid Use of Standard Library Memory Routine Error

```
#include <string.h>
#include <stdio.h>

char* Copy_First_Six_Letters(void)
 {
  char str1[10],str2[5];

  printf("Enter string:\n");
  scanf("%s",str1);
```

```
  memcpy(str2,str1,6);
  /* Defect: Arguments of memcpy invalid: str2 has size < 6 */

  return str2;
 }
```

The size of string `str2` is 5, but six characters of string `str1` are copied into `str2` using the `memcpy` function.

Correction — Call Function with Valid Arguments

One possible correction is to adjust the size of `str2` so that it accommodates the characters copied with the `memcpy` function.

```
#include <string.h>
#include <stdio.h>

char* Copy_First_Six_Letters(void)
 {
  /* Fix: Declare str2 with size 6 */
  char str1[10],str2[6];

  printf("Enter string:\n");
  scanf("%s",str1);

  memcpy(str2,str1,6);
  return str2;
 }
```

Invalid use of standard library string routine

Description

Invalid use of standard library string routine occurs when a string library function is called with invalid arguments.

Risk

The risk depends on the type of invalid arguments. For instance, using the `strcpy` function with a source argument larger than the destination argument can result in buffer overflows.

Fix

The fix depends on the standard library function involved in the defect. In some cases, you can constrain the function arguments before the function call. For instance, if the `strcpy` function:

```
char * strcpy(char * destination, const char* source)
```

tries to copy too many bytes into the destination argument compared to the available buffer, constrain the source argument before the call to `strcpy`. In some cases, you can use an alternative function to avoid the error. For instance, instead of `strcpy`, you can use `strncpy` to control the number of bytes copied. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Invalid Use of Standard Library String Routine Error

```
#include <string.h>
#include <stdio.h>

char* Copy_String(void)
{
 char *res;
 char gbuffer[5],text[20]="ABCDEFGHIJKL";

 res=strcpy(gbuffer,text);
 /* Error: Size of text is less than gbuffer */

 return(res);
}
```

The string `text` is larger in size than `gbuffer`. Therefore, the function `strcpy` cannot copy `text` into `gbuffer`.

Correction — Use Valid Arguments

One possible correction is to declare the destination string `gbuffer` with equal or larger size than the source string `text`.

```
#include <string.h>
 #include <stdio.h>
```

```
char* Copy_String(void)
{
 char *res;
 /*Fix: gbuffer has equal or larger size than text */
 char gbuffer[20],text[20]="ABCDEFGHIJKL";

 res=strcpy(gbuffer,text);

 return(res);
}
```

Destination buffer overflow in string manipulation

Description

Destination buffer overflow in string manipulation occurs when certain string manipulation functions write to their destination buffer argument at an offset greater than the buffer size.

For instance, when calling the function `sprintf(char* buffer, const char* format)`, you use a constant string `format` of greater size than `buffer`.

Risk

Buffer overflow can cause unexpected behavior such as memory corruption or stopping your system. Buffer overflow also introduces the risk of code injection.

Fix

One possible solution is to use alternative functions to constrain the number of characters written. For instance:

- If you use `sprintf` to write formatted data to a string, use `snprintf`, `_snprintf` or `sprintf_s` instead to enforce length control. Alternatively, use `asprintf` to automatically allocate the memory required for the destination buffer.
- If you use `vsprintf` to write formatted data from a variable argument list to a string, use `vsnprintf` or `vsprintf_s` instead to enforce length control.
- If you use `wcscpy` to copy a wide string, use `wcsncpy`, `wcslcpy`, or `wcscpy_s` instead to enforce length control.

Another possible solution is to increase the buffer size.

Example - Buffer Overflow in `sprintf` Use

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";

    sprintf(buffer, fmt_string);
}
```

In this example, `buffer` can contain 20 `char` elements but `fmt_string` has a greater size.

Correction — Use `snprintf` Instead of `sprintf`

One possible correction is to use the `snprintf` function to enforce length control.

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";

    snprintf(buffer, 20, fmt_string);
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [libuse]

Using an object overwritten by getenv, localeconv, setlocale, and strerror

Description

Rule Definition

Using an object overwritten by getenv, localeconv, setlocale, and strerror.

Examples

Misuse of return value from nonreentrant standard function

Description

Misuse of return value from nonreentrant standard function occurs when these events happen in this sequence:

1. You point to the buffer returned from a nonreentrant standard function such as `getenv` or `setlocale`.

   ```
   user = getenv("USER");
   ```

2. You call that nonreentrant standard function again.

   ```
   user2 = getenv("USER2");
   ```

3. You use or dereference the pointer from the first step expecting the buffer to remain unmodified since that step. In the meantime, the call in the second step has modified the buffer.

   For instance:

   ```
   var=*user;
   ```

In some cases, the defect might appear even if you do not call the `getenv` function a second time but simply return the pointer. For instance:

```
char* func() {
     user=getenv("USER");
     .
     .
     return user;
}
```

For information on which functions are covered by this defect, see documentation on nonreentrant standard functions.

Risk

The C Standard allows nonreentrant functions such as `getenv` to return a pointer to a *static* buffer. Because the buffer is static, a second call to `getenv` modifies the buffer. If you continue to use the pointer returned from the first call past the second call, you can see unexpected results. The buffer that it points to no longer has values from the first call.

The defect appears even if you do not call `getenv` a second time but simply return the pointer. The reason is that someone calling your function might use the returned pointer *after* a second call to `getenv`. By returning the pointer from your call to `getenv`, you make your function unsafe to use.

The same rationale is true for other nonreentrant functions covered by this defect.

Fix

After the first call to `getenv`, make a copy of the buffer that the returned pointer points to. After the second call to `getenv`, use this copy. Even if the second call modifies the buffer, your copy is untouched.

Example - Return from `getenv` Used After Second Call to `getenv`

```
#include <stdlib.h>
#include <string.h>

int func()
{
    int result = 0;

    char *home = getenv("HOME");   /* First call */
    if (home != NULL) {
        char *user = NULL;
        char *user_name_from_home = strrchr(home, '/');
```

```
        if (user_name_from_home != NULL) {
            user = getenv("USER");   /* Second call */
            if ((user != NULL) &&
                (strcmp(user, user_name_from_home) == 0))
            {
                result = 1;
            }
        }
    }
    return result;
}
```

In this example, the pointer `user_name_from_home` is derived from the pointer `home`. `home` points to the buffer returned from the first call to `getenv`. Therefore, `user_name_from_home` points to a location in the same buffer.

After the second call to `getenv`, the buffer is modified. If you continue to use `user_name_from_home`, you can get unexpected results.

Correction — Make Copy of Buffer Before Second Call

If you want to access the buffer from the first call to `getenv` past the second call, make a copy of the buffer after the first call. One possible correction is to use the `strdup` function to make the copy.

```
#include <stdlib.h>
#include <string.h>

int func()
{
    int result = 0;

    char *home = getenv("HOME");
    if (home != NULL) {
        char *user = NULL;
        char *user_name_from_home = strrchr(home, '/');
        if (user_name_from_home != NULL) {
            /* Make copy before second call */
            char *saved_user_name_from_home = strdup(user_name_from_home);
            if (saved_user_name_from_home != NULL) {
                user = getenv("USER");
                if ((user != NULL) &&
                    (strcmp(user, saved_user_name_from_home) == 0))
                {
```

```
                    result = 1;
                }
                free(saved_user_name_from_home);
            }
        }
    }
    return result;
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [nonnullcs]

Passing a non-null-terminated character sequence to a library function

Description

Rule Definition

Passing a non-null-terminated character sequence to a library function.

Examples

Invalid use of standard library string routine

Description

Invalid use of standard library string routine occurs when a string library function is called with invalid arguments.

Risk

The risk depends on the type of invalid arguments. For instance, using the `strcpy` function with a source argument larger than the destination argument can result in buffer overflows.

Fix

The fix depends on the standard library function involved in the defect. In some cases, you can constrain the function arguments before the function call. For instance, if the `strcpy` function:

```
char * strcpy(char * destination, const char* source)
```

tries to copy too many bytes into the destination argument compared to the available buffer, constrain the source argument before the call to `strcpy`. In some cases, you can use an alternative function to avoid the error. For instance, instead of `strcpy`, you can use `strncpy` to control the number of bytes copied. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Invalid Use of Standard Library String Routine Error

```
#include <string.h>
#include <stdio.h>

char* Copy_String(void)
{
 char *res;
 char gbuffer[5],text[20]="ABCDEFGHIJKL";

 res=strcpy(gbuffer,text);
 /* Error: Size of text is less than gbuffer */

 return(res);
}
```

The string `text` is larger in size than `gbuffer`. Therefore, the function `strcpy` cannot copy `text` into `gbuffer`.

Correction — Use Valid Arguments

One possible correction is to declare the destination string `gbuffer` with equal or larger size than the source string `text`.

```
#include <string.h>
#include <stdio.h>

char* Copy_String(void)
{
 char *res;
 /*Fix: gbuffer has equal or larger size than text */
 char gbuffer[20],text[20]="ABCDEFGHIJKL";

 res=strcpy(gbuffer,text);

 return(res);
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [nullref]

Dereferencing an out-of-domain pointer

Description

Rule Definition

Dereferencing an out-of-domain pointer.

Examples

Unsafe pointer arithmetic

Description

The issue occurs when a pointer resulting from arithmetic on a pointer operand does not address an element of the same array as that pointer operand.

Polyspace flags this rule during the analysis as:

- Bug Finder — `Array access out-of-bounds` and `Pointer access out-of-bounds`
- Code Prover — and

Bug Finder and Code Prover check this rule differently and can show different results for this rule. In Code Prover, you can also see a difference in results based on your choice for the option `Verification level (-to)`. . For more information on analysis options, see the documentation for Polyspace Code Prover or Polyspace Code Prover Server.

Risk

Using an invalid array subscript can lead to erroneous behavior of the program. Run-time derived array subscripts are especially troublesome because they cannot be easily checked by manual review or static analysis.

The C Standard defines the creation of a pointer to one beyond the end of the array. The rule permits the C Standard. Dereferencing a pointer to one beyond the end of an array causes undefined behavior and is noncompliant.

Invalid use of standard library memory routine

Description

Invalid use of standard library memory routine occurs when a memory library function is called with invalid arguments. For instance, the `memcpy` function copies to an array that cannot accommodate the number of bytes copied.

Risk

Use of a memory library function with invalid arguments can result in issues such as buffer overflow.

Fix

The fix depends on the root cause of the defect. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Invalid Use of Standard Library Memory Routine Error

```
#include <string.h>
#include <stdio.h>

char* Copy_First_Six_Letters(void)
 {
  char str1[10],str2[5];

  printf("Enter string:\n");
  scanf("%s",str1);

  memcpy(str2,str1,6);
  /* Defect: Arguments of memcpy invalid: str2 has size < 6 */
```

```
  return str2;
 }
```

The size of string `str2` is 5, but six characters of string `str1` are copied into `str2` using the `memcpy` function.

Correction — Call Function with Valid Arguments

One possible correction is to adjust the size of `str2` so that it accommodates the characters copied with the `memcpy` function.

```
#include <string.h>
#include <stdio.h>

char* Copy_First_Six_Letters(void)
 {
  /* Fix: Declare str2 with size 6 */
  char str1[10],str2[6];

  printf("Enter string:\n");
  scanf("%s",str1);

  memcpy(str2,str1,6);
  return str2;
 }
```

Null pointer

Description

Null pointer occurs when you use a pointer with a value of `NULL` as if it points to a valid memory location.

Risk

Dereferencing a null pointer is undefined behavior. In most implementations, the dereference can cause your program to crash.

Fix

Check a pointer for `NULL` before dereference.

If the issue occurs despite an earlier check for NULL, look for intermediate events between the check and the subsequent dereference. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

Example - Null pointer error

```
#include <stdlib.h>

int FindMax(int *arr, int Size)
{
 int* p=NULL;

 *p=arr[0];
 /* Defect: Null pointer dereference */

 for(int i=0;i<Size;i++)
  {
   if(arr[i] > (*p))
     *p=arr[i];
  }

 return *p;
}
```

The pointer p is initialized with value of NULL. However, when the value arr[0] is written to *p, p is assumed to point to a valid memory location.

Correction — Assign Address to Null Pointer Before Dereference

One possible correction is to initialize p with a valid memory address before dereference.

```
#include <stdlib.h>

int FindMax(int *arr, int Size)
{
 /* Fix: Assign address to null pointer */
 int* p=&arr[0];

 for(int i=0;i<Size;i++)
  {
```

```
   if(arr[i] > (*p))
     *p=arr[i];
  }

 return *p;
}
```

Arithmetic operation with NULL pointer

Description

Arithmetic operation with NULL pointer occurs when an arithmetic operation involves a pointer whose value is `NULL`.

Risk

Performing pointer arithmetic on a null pointer and dereferencing the resulting pointer is undefined behavior. In most implementations, the dereference can cause your program to crash.

Fix

Check a pointer for `NULL` before arithmetic operations on the pointer.

If the issue occurs despite an earlier check for `NULL`, look for intermediate events between the check and the subsequent dereference. Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below.

Example - Arithmetic Operation with NULL Pointer Error

```
#include<stdlib.h>

int Check_Next_Value(int *loc, int val)
 {
  int *ptr = loc, found = 0;

  if (ptr==NULL)
   {
      ptr++;
```

```
      /* Defect: NULL pointer shifted */

      if (*ptr==val) found=1;
   }

  return(found);
 }
```

When `ptr` is a `NULL` pointer, the code enters the `if` statement body. Therefore, a `NULL` pointer is shifted in the statement `ptr++`.

Correction — Avoid NULL Pointer Arithmetic

One possible correction is to perform the arithmetic operation when `ptr` is not `NULL`.

```
#include<stdlib.h>

int Check_Next_Value(int *loc, int val)
 {
  int *ptr = loc, found = 0;

  /* Fix: Perform operation when ptr is not NULL */
  if (ptr!=NULL)
   {
      ptr++;

      if (*ptr==val) found=1;
   }

  return(found);
 }
```

Invalid use of standard library string routine

Description

Invalid use of standard library string routine occurs when a string library function is called with invalid arguments.

Risk

The risk depends on the type of invalid arguments. For instance, using the `strcpy` function with a source argument larger than the destination argument can result in buffer overflows.

Fix

The fix depends on the standard library function involved in the defect. In some cases, you can constrain the function arguments before the function call. For instance, if the `strcpy` function:

```
char * strcpy(char * destination, const char* source)
```

tries to copy too many bytes into the destination argument compared to the available buffer, constrain the source argument before the call to `strcpy`. In some cases, you can use an alternative function to avoid the error. For instance, instead of `strcpy`, you can use `strncpy` to control the number of bytes copied.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Invalid Use of Standard Library String Routine Error

```
#include <string.h>
#include <stdio.h>

char* Copy_String(void)
{
 char *res;
 char gbuffer[5],text[20]="ABCDEFGHIJKL";

 res=strcpy(gbuffer,text);
 /* Error: Size of text is less than gbuffer */

 return(res);
}
```

The string `text` is larger in size than `gbuffer`. Therefore, the function `strcpy` cannot copy `text` into `gbuffer`.

Correction — Use Valid Arguments

One possible correction is to declare the destination string `gbuffer` with equal or larger size than the source string `text`.

```
#include <string.h>
 #include <stdio.h>
```

```
char* Copy_String(void)
{
 char *res;
 /*Fix: gbuffer has equal or larger size than text */
 char gbuffer[20],text[20]="ABCDEFGHIJKL";

 res=strcpy(gbuffer,text);

 return(res);
}
```

Use of tainted pointer

Description

Use of tainted pointer defect is raised when:

- Tainted NULL pointer — the pointer is not validated against NULL.
- Tainted size pointer — the size of the memory zone that a pointer points to is not validated.

Note On a single pointer, your code can have instances of **Use of tainted pointer**, **Pointer dereference with tainted offset**, and **Tainted NULL or non-null-terminated string**. Bug Finder raises only the first tainted pointer defect that it finds.

Risk

An attacker can give your program a pointer that points to unexpected memory locations. If the pointer is dereferenced to write, the attacker can:

- Modify the state variables of a critical program.
- Cause your program to crash.
- Execute unwanted code.

If the pointer is dereferenced to read, the attacker can:

- Read sensitive data.
- Cause your program to crash.

- Modify a program variable to an unexpected value.

Fix

Avoid use of pointers from external sources.

Alternatively, if you trust the external source, sanitize the pointer before dereference. In a separate sanitization function:

- Check that the pointer is not NULL.
- Check the size of the memory location (if possible). This second check validates whether the size of the data the pointer points to matches the size your program expects.

The defect still appears in the body of the sanitization function. However, if you use a sanitization function, instead of several occurrences, the defect appears only once. You can justify the defect and hide it in later reviews by using code annotations. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Function That Dereferences an External Pointer

```
void taintedptr(int* p, int i) {
    *p = i;
}
```

In this example, the pointer `*p` is passed as an argument, and the value is changed. The pointer can be null or point to unknown memory, which can be vulnerable.

Correction — Avoid Use of External Pointers

One possible correction is to avoid pointers from external sources.

```
int *taintedptr(int i) {
    /* Use heap memory allocated in the application */
    int *p = (int *)malloc(sizeof (int));
    if (p != NULL) { /* Check for success */
        *p = i;
    }
return p;
}
```

Correction — Check Pointer

Another possible correction is to sanitize the pointer before using it. This example uses a second function to check if the pointer is null and can be dereferenced.

```
#include <stdlib.h>

int* sanitize_ptr(int* p) {
    int* res = NULL;
    if (p && *p) { /* Tainted pointer detected here, used as "firewall" */
        /* Pointer is not null and dereference ok */
        res = p;
    }
    return res;
}
void taintedptr(int* p, int i) {
    p = sanitize_ptr(p);
    if (p) {
        *p = i;
    }
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [padcomp]

Comparison of padding data

Description

Rule Definition

Comparison of padding data.

Examples

Memory comparison of padding data

Description

Memory comparison of padding data occurs when you use the `memcmp` function to compare two structures as a whole. In the process, you compare meaningless data stored in the structure padding.

For instance:

```
struct structType {
    char member1;
    int member2;
    .
    .
};

structType var1;
structType var2;
.
.
if(memcmp(&var1,&var2,sizeof(var1)))
{...}
```

Risk

If members of a structure have different data types, your compiler introduces additional padding for data alignment in memory. For an example of padding, see `Higher Estimate of Local Variable Size`.

The content of these extra padding bytes is meaningless. The C Standard allows the content of these bytes to be indeterminate, giving different compilers latitude to implement their own padding. If you perform a byte-by-byte comparison of structures with `memcmp`, you compare even the meaningless data stored in the padding. You might reach the false conclusion that two data structures are not equal, even if their corresponding members have the same value.

Fix

Instead of comparing two structures in one attempt, compare the structures member by member.

For efficient code, write a function that does the comparison member by member. Use this function for comparing two structures.

You can use `memcmp` for byte-by-byte comparison of structures only if you know that the structures do not contain padding. Typically, to prevent padding, you use specific attributes or pragmas such as `#pragma pack`. However, these attributes or pragmas are not supported by all compilers and make your code implementation-dependent. If your structures contain bit-fields, using these attributes or pragmas cannot prevent padding.

Example - Structures Compared with `memcmp`

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define fatal_error() abort()

typedef struct s_padding
{
    char c;
    int i;
    unsigned int bf1:1;
    unsigned int bf2:2;
    unsigned char buffer[20];
} S_Padding ;
```

```
/* Function that guarantees safe access to the input memory */
extern int trusted_memory_zone(void *ptr, size_t sz);

int func(const S_Padding *left, const S_Padding *right)
{

    if (!trusted_memory_zone((void *)left, sizeof(S_Padding)) ||
        !trusted_memory_zone((void *)right, sizeof(S_Padding))) {
        fatal_error();
    }

    if (0 == memcmp(left, right, sizeof(S_Padding)))
    {
        return 1;
    }
    else
        return 0;
}
```

In this example, `memcmp` compares byte-by-byte the two structures that `left` and `right` point to. Even if the values stored in the structure members are the same, the comparison can show an inequality if the meaningless values in the padding bytes are not the same.

Correction — Compare Structures Member by Member

One possible correction is to compare individual structure members.

Note You can compare entire arrays by using `memcmp`. All members of an array have the same data type. Padding bytes are not required to store arrays.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define fatal_error() abort()

typedef struct s_padding
{
    char c;
    int i;
    unsigned int bf1:1;
```

```
    unsigned int bf2:2;
    unsigned char buffer[20];
} S_Padding ;

/* Function that guarantees safe access to the input memory */
extern int trusted_memory_zone(void *ptr, size_t sz);

int func(const S_Padding *left, const S_Padding *right)
{
    if (!trusted_memory_zone((void *)left, sizeof(S_Padding)) ||
        !trusted_memory_zone((void *)right, sizeof(S_Padding))) {
        fatal_error();
    }

    return ((left->c == right->c) &&
            (left->i == right->i) &&
            (left->bf1 == right->bf1) &&
            (left->bf2 == right->bf2) &&
            (memcmp(left->buffer, right->buffer, 20) == 0));
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [ptrcomp]

Accessing an object through a pointer to an incompatible type

Description

Rule Definition

Accessing an object through a pointer to an incompatible type.

Examples

Conversion between pointers to different objects

Description

The issue occurs when a cast is performed between a pointer to object type and a pointer to a different object type.

Risk

If a pointer to an object is cast into a pointer to a different object, the resulting pointer can be incorrectly aligned. The incorrect alignment causes undefined behavior.

Even if the conversion produces a pointer that is correctly aligned, the behavior can be undefined if the pointer is used to access an object.

Exception: You can convert a pointer to object type into a pointer to one of the following types:

- `char`
- `signed char`
- `unsigned char`

Example - Noncompliant: Cast to Pointer Pointing to Object of Wider Type

```
signed   char *p1;
unsigned int *p2;

void foo(void){
  p2 = ( unsigned int * ) p1;     /* Non-compliant */
}
```

In this example, `p1` can point to a `signed char` object. However, `p1` is cast to a pointer that points to an object of wider type, `unsigned int`.

Example - Noncompliant: Cast to Pointer Pointing to Object of Narrower Type

```
extern unsigned int read_value ( void );
extern void display ( unsigned int n );

void foo ( void ){
  unsigned int u = read_value ( );
  unsigned short *hi_p = ( unsigned short * ) &u;    /* Non-compliant  */
  *hi_p = 0;
  display ( u );
}
```

In this example, `u` is an `unsigned int` variable. `&u` is cast to a pointer that points to an object of narrower type, `unsigned short`.

On a big-endian machine, the statement `*hi_p = 0` attempts to clear the high bits of the memory location that `&u` points to. But, from the result of `display(u)`, you might find that the high bits have not been cleared.

Example - Compliant: Cast Adding a Type Qualifier

```
const short *p;
const volatile short *q;
void foo (void){
  q = ( const volatile short * ) p;  /* Compliant */
}
```

In this example, both `p` and `q` can point to `short` objects. The cast between them adds a `volatile` qualifier only and is therefore compliant.

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [ptrobj]

Subtracting or comparing two pointers that do not refer to the same array

Description

Rule Definition

Subtracting or comparing two pointers that do not refer to the same array.

Examples

Subtraction or comparison between pointers to different arrays

Description

Subtraction or comparison between pointers to different arrays occurs when you subtract or compare pointers that are null or that point to elements in different arrays. The relational operators for the comparison are >, <, >=, and <=.

Risk

When you subtract two pointers to elements in the same array, the result is the difference between the subscripts of the two array elements. Similarly, when you compare two pointers to array elements, the result is the positions of the pointers relative to each other. If the pointers are null or point to different arrays, a subtraction or comparison operation is undefined. If you use the subtraction result as a buffer index, it can cause a buffer overflow.

Fix

Before you subtract or use relational operators to compare pointers to array elements, check that they are non-null and that they point to the same array.

Example - Subtraction Between Pointers to Elements in Different Arrays

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define SIZE20 20

size_t func(void)
{
    int nums[SIZE20];
    int end;
    int *next_num_ptr = nums;
    size_t free_elements;
    /* Increment next_num_ptr as array fills */

    /* Subtraction operation is undefined unless array nums
    is adjacent to variable end in memory. */
    free_elements = &end - next_num_ptr;
    return free_elements;
}
```

In this example, the array `nums` is incrementally filled. Pointer subtraction is then used to determine how many free elements remain. Unless `end` points to a memory location one past the last element of `nums`, the subtraction operation is undefined.

Correction — Subtract Pointers to the Same Array

Subtract the pointer to the last element that was filled from the pointer to the last element in the array.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define SIZE20 20

size_t func(void)
{
    int nums[SIZE20];
    int *next_num_ptr = nums;
    size_t free_elements;
```

```
    /* Increment next_num_ptr as array fills */

    /* Subtraction operation involves pointers to the same array. */
    free_elements = &(nums[SIZE20 - 1]) - next_num_ptr;

    return free_elements + 1;
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [resident]

Using identifiers that are reserved for the implementation

Description

Rule Definition

Using identifiers that are reserved for the implementation.

Examples

Declaration of reserved identifiers or macro names

Description

The issue occurs when a reserved identifier or macro name is declared.

If you define a macro name that corresponds to a standard library macro, object, or function, rule 21.1 is violated.

The rule considers tentative definitions as definitions.

Risk

The Standard allows implementations to treat reserved identifiers specially. If you reuse reserved identifiers, you can cause undefined behavior.

Check Information

Decidability: Decidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [restrict]

Passing pointers into the same object as arguments to different restrict-qualified parameters

Description

Rule Definition

Passing pointers into the same object as arguments to different restrict-qualified parameters.

Examples

Copy of overlapping memory

Description

Copy of overlapping memory occurs when there is a memory overlap between the source and destination argument of a copy function such as `memcpy` or `strcpy`. For instance, the source and destination arguments of `strcpy` are pointers to different elements in the same string.

Risk

If there is memory overlap between the source and destination arguments of copy functions, according to C standards, the behavior is undefined.

Fix

Determine if the memory overlap is what you want. If so, find an alternative function. For instance:

- If you are using `memcpy` to copy values from one memory location to another, use `memmove` instead of `memcpy`.

- If you are using `strcpy` to copy one string to another, use `memmove` instead of `strcpy`, as follows:

  ```
  s = strlen(source);
  memmove(destination, source, s + 1);
  ```

  `strlen` determines the string length without the null terminator. Therefore, you must move `s+1` bytes instead of `s` bytes.

Example - Overlapping Copy

```
#include <string.h>

char str[] = {"ABCDEFGH"};

void my_copy() {
    strcpy(&str[0],(const char*)&str[2]);
}
```

In this example, because the source and destination argument are pointers to the same string `str`, there is memory overlap between their allowed buffers.

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [sigcall]

Calling signal from interruptible signal handlers

Description

Rule Definition

Calling signal from interruptible signal handlers.

Examples

Signal call from within signal handler

Description

Signal call from within signal handler occurs when you call `signal()` from a nonpersistent signal handler on a Windows platform.

Risk

A nonpersistent signal handler is reset after catching a signal. The handler does not catch subsequent signals unless the handler is reestablished by calling `signal()`. A nonpersistent signal handler on a Windows platform is reset to `SIG_DFL`. If another signal interrupts the execution of the handler, that signal can cause a race condition between `SIG_DFL` and the existing signal handler. A call to `signal()` can also result in an infinite loop inside the handler.

Fix

Do not call `signal()` from a signal handler on Windows platforms.

Example - `signal()` Called from Signal Handler

```
#include <stdio.h>
#include <stdlib.h>
```

```
#include <signal.h>
#include <unistd.h>



volatile sig_atomic_t e_flag = 0;

void sig_handler(int signum)
{
    int s0 = signum;
    e_flag = 1;

    /* Call signal() to reestablish sig_handler
    upon receiving SIG_ERR. */

    if (signal(s0, sig_handler) == SIG_ERR)
    {
        /* Handle error */
    }
}

void func(void)
{
        if (signal(SIGINT, sig_handler) == SIG_ERR)
        {
            /* Handle error */

        }
  /* more code */
}
```

In this example, the definition of `sig_handler()` includes a call to `signal()` when the handler catches `SIG_ERR`. On Windows platforms, signal handlers are nonpersistent. This code can result in a race condition.

Correction — Do Not Call `signal()` from Signal Handler

If your code requires the use of a persistent signal handler on a Windows platform, use a persistent signal handler after performing a thorough risk analysis.

```
#include <stdio.h>
#include <stdlib.h>
#include <signal.h>
```

```
#include <unistd.h>


volatile sig_atomic_t e_flag = 0;


void sig_handler(int signum)
{
    int s0 = signum;
    e_flag = 1;
    /* No call to signal() */
}

int main(void)
{

        if (signal(SIGINT, sig_handler) == SIG_ERR)
        {
            /* Handle error */

        }
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [signconv]

Conversion of signed characters to wider integer types before a check for EOF

Description

Rule Definition

Conversion of signed characters to wider integer types before a check for EOF.

Examples

Misuse of sign-extended character value

Description

Misuse of sign-extended character value occurs when you convert a signed or plain `char` data type to a wider integer data type with sign extension. You then use the resulting sign-extended value as array index, for comparison with EOF or as argument to a character-handling function.

Risk

Comparison with EOF: Suppose, your compiler implements the plain `char` type as signed. In this implementation, the character with the decimal form of 255 (–1 in two's complement form) is stored as a signed value. When you convert a `char` variable to the wider data type `int` for instance, the sign bit is preserved (sign extension). This sign extension results in the character with the decimal form 255 being converted to the integer –1, which cannot be distinguished from EOF.

Use as array index: By similar reasoning, you cannot use sign-extended plain `char` variables as array index. If the sign bit is preserved, the conversion from `char` to `int` can result in negative integers. You must use positive integer values for array index.

Argument to character-handling function: By similar reasoning, you cannot use sign-extended plain `char` variables as arguments to character-handling functions declared in

`ctype.h`, for instance, `isalpha()` or `isdigit()`. According to the C11 standard (Section 7.4), if you supply an integer argument that cannot be represented as `unsigned char` or EOF, the resulting behavior is undefined.

Fix

Before conversion to a wider integer data type, cast the signed or plain `char` value explicitly to `unsigned char`.

Example - Sign-Extended Character Value Compared with EOF

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

extern char parsed_token_buffer[20];

static int parser(char *buf)
{
    int c = EOF;
    if (buf && *buf) {
        c = *buf++;
    }
    return c;
}

void func()
{
    if (parser(parsed_token_buffer) == EOF) {
        /* Handle error */
        fatal_error();
    }
}
```

In this example, the function `parser` can traverse a string input `buf`. If a character in the string has the decimal form 255, when converted to the `int` variable `c`, its value becomes –1, which is indistinguishable from `EOF`. The later comparison with `EOF` can lead to a false positive.

Correction — Cast to `unsigned char` Before Conversion

One possible correction is to cast the plain `char` value to `unsigned char` before conversion to the wider `int` type.

```
#include <stdio.h>
#include <stdlib.h>
#define fatal_error() abort()

extern char parsed_token_buffer[20];

static int parser(char *buf)
{
    int c = EOF;
    if (buf && *buf) {
        c = (unsigned char)*buf++;
    }
    return c;
}

void func()
{
    if (parser(parsed_token_buffer) == EOF) {
        /* Handle error */
        fatal_error();
    }
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [sizeofptr]

Taking the size of a pointer to determine the size of the pointed-to type

Description

Rule Definition

Taking the size of a pointer to determine the size of the pointed-to type.

Examples

Possible misuse of sizeof

Description

Possible misuse of sizeof occurs when Polyspace Bug Finder detects possibly unintended results from the use of `sizeof` operator. For instance:

- You use the `sizeof` operator on an array parameter name, expecting the array size. However, the array parameter name by itself is a pointer. The `sizeof` operator returns the size of that pointer.
- You use the `sizeof` operator on an array element, expecting the array size. However, the operator returns the size of the array element.
- The size argument of certain functions such as `strncmp` or `wcsncpy` is incorrect because you used the `sizeof` operator earlier with possibly incorrect expectations. For instance:
  - In a function call `strncmp(string1, string2, num)`, `num` is obtained from an incorrect use of the `sizeof` operator on a pointer.
  - In a function call `wcsncpy(destination, source, num)`, `num` is the not the number of wide characters but a size in bytes obtained by using the `sizeof` operator. For instance, you use `wcsncpy(destination, source, sizeof(destination) - 1)` instead of `wcsncpy(destination, source, (sizeof(desintation)/sizeof(wchar_t)) - 1)`.

Risk

Incorrect use of the `sizeof` operator can cause the following issues:

- If you expect the `sizeof` operator to return array size and use the return value to constrain a loop, the number of loop runs are smaller than what you expect.
- If you use the return value of `sizeof` operator to allocate a buffer, the buffer size is smaller than what you require. Insufficient buffer can lead to resultant weaknesses such as buffer overflows.
- If you use the return value of `sizeof` operator incorrectly in a function call, the function does not behave as you expect.

Fix

Possible fixes are:

- Do not use the `sizeof` operator on an array parameter name or array element to determine array size.

  The best practice is to pass the array size as a separate function parameter and use that parameter in the function body.
- Use the `sizeof` operator carefully to determine the number argument of functions such as `strncmp` or `wcsncpy`. For instance, for wide string functions such as `wcsncpy`, use the number of wide characters as argument instead of the number of bytes.

Example - `sizeof` Used Incorrectly to Determine Array Size

```
#define MAX_SIZE 1024

void func(int a[MAX_SIZE]) {
    int i;

    for (i = 0; i < sizeof(a)/sizeof(int); i++)    {
        a[i] = i + 1;
    }
}
```

In this example, `sizeof(a)` returns the size of the pointer `a` and not the array size.

Correction — Determine Array Size in Another Way

One possible correction is to use another means to determine the array size.

```
#define MAX_SIZE 1024

void func(int a[MAX_SIZE]) {
    int i;

    for (i = 0; i < MAX_SIZE; i++)    {
        a[i] = i + 1;
    }
}
```

Check Information

Decidability: Decidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [strmod]

Modifying string literals

Description

Rule Definition

Modifying string literals.

Examples

Writing to const qualified object

Description

Writing to `const` qualified object occurs when you do one of the following:

- Use a `const`-qualified object as the destination of an assignment.
- Pass a `const`-qualified object to a function that modifies the argument.

For instance, the defect can occur in the following situations:

- You pass a `const`-qualified object as first argument of one of the following functions:
  - `mkstemp`
  - `mkostemp`
  - `mkostemps`
  - `mkdtemp`
- You pass a `const`-qualified object as the destination argument of one of the following functions:
  - `strcpy`
  - `strncpy`

  - `strcat`
  - `memset`
- You perform a write operation on a `const`-qualified object.

Risk

The risk depends upon the modifications made to the `const`-qualified object.

Situation	Risk
Passing to `mkstemp`, `mkostemp`, `mkostemps`, `mkdtemp`, and so on.	These functions replace the last six characters of their first argument with a string. Therefore, they expect a modifiable `char` array as their first argument.
Passing to `strcpy`, `strncpy`, `strcat`, `memset` and so on.	These functions modify their destination argument. Therefore, they expect a modifiable `char` array as their destination argument.
Writing to the object	The `const` qualifier implies an agreement that the value of the object will not be modified. By writing to a `const`-qualified object, you break the agreement. The result of the operation is undefined.

Fix

The fix depends on the modification made to the `const`-qualified object.

Situation	Fix
Passing to `mkstemp`, `mkostemp`, `mkostemps`, `mkdtemp`, and so on.	Pass a non-`const` object as first argument of the function.
Passing to `strcpy`, `strncpy`, `strcat`, `memset` and so on.	Pass a non-`const` object as destination argument of the function.
Writing to the object	Perform the write operation on a non-`const` object.

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Writing to const-Qualified Object

```
#include <string.h>

const char* buffer = "abcdeXXXXXXX";

void func(char* string) {
    char *ptr = (char*)strchr(buffer,'X');
    if(ptr)
        strcpy(ptr,string);
}
```

In this example, because `buffer` is `const`-qualified, `strchr(buffer,'X')` returns a `const`-qualified `char*` pointer. When this `char*` pointer is used as the destination argument of `strcpy`, a **Writing to const qualified object** error appears.

Correction — Copy const-Qualified Object to Non-const Object

One possible correction is to assign the constant string to a non-`const` object and use the non-`const` object as destination argument of `strchr`.

```
#include <string.h>

char buffer[] = "abcdeXXXXXXX";

void func(char* string) {
    char *ptr = (char*)strchr(buffer,'X');
    if(ptr)
        strcpy(ptr,string);
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [swtchdflt]

Use of an implied default in a switch statement

Description

Rule Definition

Use of an implied default in a switch statement.

Examples

Missing case for switch condition

Description

Missing case for switch condition occurs when the `switch` variable can take values that are not covered by a `case` statement.

Note Bug Finder only raises a defect if the switch variable is not full range.

Risk

If the `switch` variable takes a value that is not covered by a `case` statement, your program can have unintended behavior.

A switch-statement that makes a security decision is particularly vulnerable when all possible values are not explicitly handled. An attacker can use this situation to deviate the normal execution flow.

Fix

It is good practice to use a `default` statement as a catch-all for values that are not covered by a `case` statement. Even if the `switch` variable takes an unintended value, the resulting behavior can be anticipated.

Example - Missing Default Condition

```
#include <stdio.h>
#include <string.h>

typedef enum E
{
    ADMIN=1,
    GUEST,
    UNKNOWN = 0
} LOGIN;

static LOGIN system_access(const char *username) {
  LOGIN user = UNKNOWN;

  if ( strcmp(username, "root") == 0 )
    user = ADMIN;

  if ( strcmp(username, "friend") == 0 )
    user = GUEST;

  return user;
}

int identify_bad_user(const char * username)
{
    int r=0;

    switch( system_access(username) )
    {
    case ADMIN:
        r = 1;
        break;
    case GUEST:
        r = 2;
    }

    printf("Welcome!\n");
    return r;
}
```

In this example, the `enum` parameter `User` can take a value `UNKNOWN` that is not covered by a `case` statement.

Correction — Add a Default Condition

One possible correction is to add a default condition for possible values that are not covered by a `case` statement.

```
#include <stdio.h>
#include <string.h>

typedef enum E
{
    ADMIN=1,
    GUEST,
    UNKNOWN = 0
} LOGIN;

static LOGIN system_access(const char *username) {
  LOGIN user = UNKNOWN;

  if ( strcmp(username, "root") == 0 )
    user = ADMIN;

  if ( strcmp(username, "friend") == 0 )
    user = GUEST;

  return user;
}

int identify_bad_user(const char * username)
{
    int r=0;

    switch( system_access(username) )
    {
    case ADMIN:
        r = 1;
        break;
    case GUEST:
        r = 2;
    break;
    default:
        printf("Invalid login credentials!\n");
    }

    printf("Welcome!\n");
```

```
    return r;
}
```

Check Information

Decidability: Decidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [syscall]

Calling system

Description

Rule Definition

Calling system.

Examples

Unsafe call to a system function

Description

Unsafe call to a system function occurs when you use a function that invokes an implementation-defined command processor. These functions include:

- The C standard `system()` function.
- The POSIX `popen()` function.
- The Windows `_popen()` and `_wpopen()` functions.

Risk

If the argument of a function that invokes a command processor is not sanitized, it can cause exploitable vulnerabilities. An attacker can execute arbitrary commands or read and modify data anywhere on the system.

Fix

Do not use a `system`-family function to invoke a command processor. Instead, use safer functions such as POSIX `execve()` and WinAPI `CreateProcess()`.

Example - `system()` Called

```
# include <string.h>
# include <stdlib.h>
# include <stdio.h>
# include <unistd.h>

enum {
SIZE512=512,
SIZE3=3};

void func(char *arg)
{
    char buf[SIZE512];
    int retval=sprintf(buf, "/usr/bin/any_cmd %s", arg);

    if (retval<=0 || retval>SIZE512){
        /* Handle error */
        abort();
    }
    /* Use of system() to pass any_cmd with
    unsanitized argument to command processor */

    if (system(buf) == -1) {
    /* Handle error */
  }
}
```

In this example, `system()` passes its argument to the host environment for the command processor to execute. This code is vulnerable to an attack by command-injection.

Correction — Sanitize Argument and Use `execve()`

In the following code, the argument of `any_cmd` is sanitized, and then passed to `execve()` for execution. `exec`-family functions are not vulnerable to command-injection attacks.

```
# include <string.h>
# include <stdlib.h>
# include <stdio.h>
# include <unistd.h>

enum {
SIZE512=512,
```

```
SIZE3=3};


void func(char *arg)
{
  char *const args[SIZE3] = {"any_cmd", arg, NULL};
  char  *const env[] = {NULL};

  /* Sanitize argument */

  /* Use execve() to execute any_cmd. */

  if (execve("/usr/bin/time", args, env) == -1) {
    /* Handle error */
  }
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [taintformatio]

Using a tainted value to write to an object using a formatted input or output function

Description

Rule Definition

Using a tainted value to write to an object using a formatted input or output function.

Examples

Use of Standard Library input/output functions

Description

The issue occurs when Standard Library input/output functions are used.

If the Standard Library function is a macro and the macro is expanded in the code, this rule is violated. It is assumed that rule 21.2 is not violated.

Risk

This rule applies to the functions that are provided by `<stdio.h>` and in C99, their character-wide equivalents provided by `<wchar.h>`. Using these functions can cause unspecified, undefined and implementation-defined behavior.

Invalid use of standard library string routine

Description

Invalid use of standard library string routine occurs when a string library function is called with invalid arguments.

Risk

The risk depends on the type of invalid arguments. For instance, using the `strcpy` function with a source argument larger than the destination argument can result in buffer overflows.

Fix

The fix depends on the standard library function involved in the defect. In some cases, you can constrain the function arguments before the function call. For instance, if the `strcpy` function:

```
char * strcpy(char * destination, const char* source)
```

tries to copy too many bytes into the destination argument compared to the available buffer, constrain the source argument before the call to `strcpy`. In some cases, you can use an alternative function to avoid the error. For instance, instead of `strcpy`, you can use `strncpy` to control the number of bytes copied. See also .

See examples of fixes below.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Invalid Use of Standard Library String Routine Error

```
#include <string.h>
#include <stdio.h>

char* Copy_String(void)
{
 char *res;
 char gbuffer[5],text[20]="ABCDEFGHIJKL";

 res=strcpy(gbuffer,text);
 /* Error: Size of text is less than gbuffer */

 return(res);
}
```

The string `text` is larger in size than `gbuffer`. Therefore, the function `strcpy` cannot copy `text` into `gbuffer`.

Correction — Use Valid Arguments

One possible correction is to declare the destination string `gbuffer` with equal or larger size than the source string `text`.

```
#include <string.h>
 #include <stdio.h>

 char* Copy_String(void)
 {
  char *res;
  /*Fix: gbuffer has equal or larger size than text */
  char gbuffer[20],text[20]="ABCDEFGHIJKL";

  res=strcpy(gbuffer,text);

  return(res);
 }
```

Buffer overflow from incorrect string format specifier

Description

Buffer overflow from incorrect string format specifier occurs when the format specifier argument for functions such as `sscanf` leads to an overflow or underflow in the memory buffer argument.

Risk

If the format specifier specifies a precision that is greater than the memory buffer size, an overflow occurs. Overflows can cause unexpected behavior such as memory corruption.

Fix

Use a format specifier that is compatible with the memory buffer size.

Example - Memory Buffer Overflow

```
#include <stdio.h>

void func (char *str[]) {
    char buf[32];
    sscanf(str[1], "%33c", buf);
}
```

In this example, `buf` can contain 32 `char` elements. Therefore, the format specifier `%33c` causes a buffer overflow.

Correction — Use Smaller Precision in Format Specifier

One possible correction is to use a smaller precision in the format specifier.

```
#include <stdio.h>

void func (char *str[]) {
    char buf[32];
    sscanf(str[1], "%32c", buf);
}
```

Destination buffer overflow in string manipulation

Description

Destination buffer overflow in string manipulation occurs when certain string manipulation functions write to their destination buffer argument at an offset greater than the buffer size.

For instance, when calling the function `sprintf(char* buffer, const char* format)`, you use a constant string `format` of greater size than `buffer`.

Risk

Buffer overflow can cause unexpected behavior such as memory corruption or stopping your system. Buffer overflow also introduces the risk of code injection.

Fix

One possible solution is to use alternative functions to constrain the number of characters written. For instance:

- If you use `sprintf` to write formatted data to a string, use `snprintf`, `_snprintf` or `sprintf_s` instead to enforce length control. Alternatively, use `asprintf` to automatically allocate the memory required for the destination buffer.
- If you use `vsprintf` to write formatted data from a variable argument list to a string, use `vsnprintf` or `vsprintf_s` instead to enforce length control.
- If you use `wcscpy` to copy a wide string, use `wcsncpy`, `wcslcpy`, or `wcscpy_s` instead to enforce length control.

Another possible solution is to increase the buffer size.

Example - Buffer Overflow in `sprintf` Use

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";

    sprintf(buffer, fmt_string);
}
```

In this example, `buffer` can contain 20 `char` elements but `fmt_string` has a greater size.

Correction — Use `snprintf` Instead of `sprintf`

One possible correction is to use the `snprintf` function to enforce length control.

```
#include <stdio.h>

void func(void) {
    char buffer[20];
    char *fmt_string = "This is a very long string, it does not fit in the buffer";

    snprintf(buffer, 20, fmt_string);
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [taintnoproto]

Using a tainted value as an argument to an unprototyped function pointer

Description

Rule Definition

Using a tainted value as an argument to an unprototyped function pointer.

Examples

Call through non-prototyped function pointer

Description

Call through non-prototyped function pointer detects a call to a function through a pointer without a prototype. A function prototype specifies the type and number of parameters.

Risk

Arguments passed to a function without a prototype might not match the number and type of parameters of the function definition, which can cause undefined behavior. If the parameters are restricted to a subset of their type domain, arguments from untrusted sources can trigger vulnerabilities in the called function.

Fix

Before calling the function through a pointer, provide a function prototype.

Example - Argument Does Not Match Parameter Restriction

```
#include <stdio.h>
#include <limits.h>
#define SIZE2 2
```

```
typedef void (*func_ptr)();
extern int getchar_wrapper(void);
extern void restricted_int_sink(int i);
/* Integer value restricted to
range [-1, 255] */
extern void restricted_float_sink(double i);
/* Double value restricted to > 0.0 */



func_ptr generic_callback[SIZE2] =
{
    (func_ptr)restricted_int_sink,
    (func_ptr)restricted_float_sink
};

void func(void)
{
    int ic;
    ic = getchar_wrapper();
    /* Wrong index used for generic_callback.
    Negative 'int' passed to restricted_float_sink. */
    (*generic_callback[1])(ic);
}
```

In this example, a call through `func_ptr` passes `ic` as an argument to function `generic_callback[1]`. The type of `ic` can have negative values, while the parameter of `generic_callback[1]` is restricted to float values greater than `0.0`. Typically, compilers and static analysis tools cannot perform type checking when you do not provide a pointer prototype.

Correction — Provide Prototype of Pointer to Function

Pass the argument `ic` to a function with a parameter of type `int`, by using a properly prototyped pointer.

```
#include <stdio.h>
#include <limits.h>
#define SIZE2 2

typedef void (*func_ptr_proto)(int);
```

```
extern int getchar_wrapper(void);
extern void restricted_int_sink(int i);
/* Integer value restricted to
range [-1, 255] */
extern void restricted_float_sink(double i);
/* Double value restricted to > 0.0 */

func_ptr_proto generic_callback[SIZE2] =
{
    (func_ptr_proto)restricted_int_sink,
    (func_ptr_proto)restricted_float_sink
};

void func(void)
{
    int ic;
    ic = getchar_wrapper();
    /* ic passed to function through
properly prototyped pointer. */
    (*generic_callback[0])(ic);
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [taintsink]

Tainted, potentially mutilated, or out-of-domain integer values are used in a restricted sink

Description

Rule Definition

Tainted, potentially mutilated, or out-of-domain integer values are used in a restricted sink.

Examples

Tainted size of variable length array

Description

Tainted size of variable length array detects variable length arrays (VLA) whose size is from an unsecure source.

Risk

If an attacker changed the size of your VLA to an unexpected value, it can cause your program to crash or behave unexpectedly.

If the size is non-positive, the behavior of the VLA is undefined. Your program does not perform as expected.

If the size is unbounded, the VLA can cause memory exhaustion or stack overflow.

Fix

Validate your VLA size to make sure that it is positive and less than a maximum value.

Example - Input Argument Used as Size of VLA

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int taintedvlasize(int size) {

    int tabvla[size];
    int res = 0;
    for (int i=0 ; i<SIZE10 ; ++i) {
        tabvla[i] = i*i;
        res += tabvla[i];
    }
    return res;
}
```

In this example, a variable length array size is based on an input argument. Because this input argument value is not checked, the size may be negative or too large.

Correction — Check VLA Size

One possible correction is to check the size variable before creating the variable length array. This example checks if the size is larger than 10 and less than 100, before creating the VLA

```
enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};

int taintedvlasize(int size) {
    int res = 0;
    if (size>SIZE10 && size<SIZE100) {
        int tabvla[size];
        for (int i=0 ; i<SIZE10 ; ++i) {
            tabvla[i] = i*i;
            res += tabvla[i];
        }
    }
    return res;
}
```

Pointer dereference with tainted offset

Description

Pointer dereference with tainted offset detects pointer dereferencing, either reading or writing, using an offset variable from an unknown or unsecure source.

This check focuses on dynamically allocated buffers. For static buffer offsets, see `Array access with tainted index`.

Risk

The index might be outside the valid array range. If the tainted index is outside the array range, it can cause:

- Buffer underflow/underwrite, or writing to memory before the beginning of the buffer.
- Buffer overflow, or writing to memory after the end of a buffer.
- Over reading a buffer, or accessing memory after the end of the targeted buffer.
- Under-reading a buffer, or accessing memory before the beginning of the targeted buffer.

An attacker can use an invalid read or write to compromise your program.

Fix

Validate the index before you use the variable to access the pointer. Check to make sure that the variable is inside the valid range and does not overflow.

Example - Dereference Pointer Array

```
#include <stdlib.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};
extern void read_pint(int*);

int taintedptroffset(int i) {
    int* pint = (int*)calloc(SIZE10, sizeof(int));
    int c = 0;
```

```
    if(pint) {
        /* Filling array */
        read_pint(pint);
        c = pint[i];
        free(pint);
    }
    return c;
}
```

In this example, the function initializes an integer pointer `pint`. The pointer is dereferenced using the input index `i`. The value of `i` could be outside the pointer range, causing an out-of-range error.

Correction — Check Index Before Dereference

One possible correction is to validate the value of the index. If the index is inside the valid range, continue with the pointer dereferencing.

```
#include <stdlib.h>

enum {
    SIZE10  =  10,
    SIZE100 = 100,
    SIZE128 = 128
};
extern void read_pint(int*);

int taintedptroffset(int i) {
    int* pint = (int*)calloc(SIZE10, sizeof(int));
    int c = 0;
    if (pint) {
        /* Filling array */
        read_pint(pint);
        if (i>0 && i<SIZE10) {
            c = pint[i];
        }
        free(pint);
    }
    return c;
}
```

Array access with tainted index

Description

Array access with tainted index detects reading or writing to an array by using a tainted index that has not been validated.

Risk

The index might be outside the valid array range. If the tainted index is outside the array range, it can cause:

- Buffer underflow/underwrite — writing to memory before the beginning of the buffer.
- Buffer overflow — writing to memory after the end of a buffer.
- Over-reading a buffer — accessing memory after the end of the targeted buffer.
- Under-reading a buffer, or accessing memory before the beginning of the targeted buffer.

An attacker can use an invalid read or write operation create to problems in your program.

Fix

Before using the index to access the array, validate the index value to make sure that it is inside the array range.

Example - Use Index to Return Buffer Value

```
#define SIZE100 100
extern int tab[SIZE100];

int taintedarrayindex(int num) {
    return tab[num];
}
```

In this example, the index `num` accesses the array `tab`. The function does not check to see if `num` is inside the range of `tab`.

Correction — Check Range Before Use

One possible correction is to check that `num` is in range before using it.

```
#define SIZE100 100
extern int tab[SIZE100];

int taintedarrayindex(int num) {
    if (num >= 0 && num < SIZE100) {
           return tab[num];
    } else {
        return -9999;
    }
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [taintstrcpy]

Tainted strings are passed to a string copying function

Description

Rule Definition

Tainted strings are passed to a string copying function.

Examples

Tainted NULL or non-null-terminated string

Description

Tainted NULL or non-null-terminated string looks for strings from unsecure sources that are being used in string manipulation routines that implicitly dereference the string buffer. For example, `strcpy` or `sprintf`.

Tainted NULL or non-null-terminated string raises no defect for a string returned from a call to `scanf`-family variadic functions. Similarly, no defect is raised when you pass the string with a `%s` specifier to `printf`-family variadic functions.

Note If you reference a string using the form `ptr[i]`, `*ptr`, or pointer arithmetic, Bug Finder raises a **Use of tainted pointer** defect instead. The **Tainted NULL or non-null-terminated string** defect is raised only when the pointer is used as a string.

Risk

If a string is from an unsecure source, it is possible that an attacker manipulated the string or pointed the string pointer to a different memory location.

If the string is NULL, the string routine cannot dereference the string, causing the program to crash. If the string is not null-terminated, the string routine might not know

when the string ends. This error can cause you to write out of bounds, causing a buffer overflow.

Fix

Validate the string before you use it. Check that:

- The string is not NULL.
- The string is null-terminated
- The size of the string matches the expected size.

Example - Getting String from Input Argument

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128

extern void print_str(const char*);

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}
```

In this example, the string `str` is concatenated with the argument `userstr`. The value of `userstr` is unknown. If the size of `userstr` is greater than the space available, the concatenation overflows.

Correction — Validate the Data

One possible correction is to check the size of `userstr` and make sure that the string is null-terminated before using it in `strncat`. This example uses a helper function, `sansitize_str`, to validate the string. The defects are concentrated in this function.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128

extern void print_str(const char*);

int sanitize_str(char* s) {
  int res = 0;
  if (s && (strlen(s) > 0)) { // TAINTED_STRING only flagged here
    // - string is not null
    // - string has a positive and limited size
    // - TAINTED_STRING on strlen used as a firewall
    res = 1;
  }
  return res;
}

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    if (sanitize_str(userstr))
      strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  if (sanitize_str(userstr))
    strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}
```

Correction — Validate the Data

Another possible correction is to call function `errorMsg` and `warningMsg` with specific strings.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define SIZE128 128
```

```
extern void print_str(const char*);

void warningMsg(char* userstr)
{
    char str[SIZE128] = "Warning: ";
    strncat(str, userstr, SIZE128-(strlen(str)+1));
    print_str(str);
}

void errorMsg(char* userstr)
{
  char str[SIZE128] = "Error: ";
  strncat(str, userstr, SIZE128-(strlen(str)+1));
  print_str(str);
}

int manageSensorValue(int sensorValue) {
  int ret = sensorValue;
  if ( sensorValue < 0 ) {
    errorMsg("sensor value should be positive");
    exit(1);
  } else if ( sensorValue > 50 ) {
    warningMsg("sensor value greater than 50 (applying threshold)...");
    sensorValue = 50;
  }

  return sensorValue;
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [uninitref]

Referencing uninitialized memory

Description

Rule Definition

Referencing uninitialized memory.

Examples

Non-initialized pointer

Description

Non-initialized pointer occurs when a pointer is not assigned an address before dereference.

Risk

Unless a pointer is explicitly assigned an address, it points to an unpredictable location.

Fix

The fix depends on the root cause of the defect. For instance, you assigned an address to the pointer but the assignment is unreachable.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below. It is a good practice to initialize a pointer to NULL when declaring the pointer.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Non-initialized pointer error

```
#include <stdlib.h>

int* assign_pointer(int* prev)
{
    int j = 42;
    int* pi;

    if (prev == NULL)
      {
        pi = (int*)malloc(sizeof(int));
        if (pi == NULL) return NULL;
      }

    *pi = j;
    /* Defect: Writing to uninitialized pointer */

    return pi;
}
```

If `prev` is not `NULL`, the pointer `pi` is not assigned an address. However, `pi` is dereferenced on every execution paths, irrespective of whether `prev` is `NULL` or not.

Correction — Initialize Pointer on Every Execution Path

One possible correction is to assign an address to `pi` when `prev` is not `NULL`.

```
#include <stdlib.h>

int* assign_pointer(int* prev)
{
    int j = 42;
    int* pi;

    if (prev == NULL)
       {
        pi = (int*)malloc(sizeof(int));
        if (pi == NULL) return NULL;
       }
    /* Fix: Initialize pi in branches of if statement  */
    else
```

```
        pi = prev;


    *pi = j;

    return pi;
}
```

Pointer to non-initialized value converted to const pointer

Description

Pointer to non initialized value converted to const pointer occurs when a pointer to a constant (`const int*`, `const char*`, etc.) is assigned an address that does not yet contain a value.

Risk

A pointer to a constant stores a value that must not be changed later in the program. If you assign the address of a non-initialized variable to the pointer, it now points to an address with garbage values for the remainder of the program.

Fix

Initialize a variable before assigning its address to a pointer to a constant.

Example - Pointer to non initialized value converted to const pointer error

```
#include<stdio.h>

void Display_Parity()
 {
  int num,parity;
  const int* num_ptr = &num;
  /* Defect: Address &num does not store a value */

  printf("Enter a number\n:");
  scanf("%d",&num);

  parity=((*num_ptr)%2);
  if(parity==0)
    printf("The number is even.");
  else
```

```
    printf("The number is odd.");

 }
```

`num_ptr` is declared as a pointer to a constant. However the variable `num` does not contain a value when `num_ptr` is assigned the address `&num`.

Correction — Store Value in Address Before Assignment to Pointer

One possible correction is to obtain the value of `num` from the user before `&num` is assigned to `num_ptr`.

```
#include<stdio.h>

void Display_Parity()
 {
  int num,parity;
  const int* num_ptr;

  printf("Enter a number\n:");
  scanf("%d",&num);

 /* Fix: Assign &num to pointer after it receives a value */
  num_ptr=&num;
  parity=((*num_ptr)%2);
  if(parity==0)
    printf("The number is even.");
  else
    printf("The number is odd.");
 }
```

The `scanf` statement stores a value in `&num`. Once the value is stored, it is legitimate to assign `&num` to `num_ptr`.

Non-initialized variable

Description

Non-initialized variable occurs when a variable is not initialized before its value is read.

Risk

Unless a variable is explicitly initialized, the variable value is unpredictable. You cannot rely on the variable having a specific value.

Fix

The fix depends on the root cause of the defect. For instance, you assigned a value to the variable but the assignment is unreachable or you assigned a value to the variable in one of two branches of a conditional statement. Fix the unreachable code or missing assignment.

Often the result details show a sequence of events that led to the defect. You can implement the fix on any event in the sequence. If the result details do not show the event history, you can trace back using right-click options in the source code and see previous related events. See also .

See examples of fixes below. It is a good practice to initialize a variable at declaration.

If you do not want to fix the issue, add comments to your result or code to avoid another review. See “Address Polyspace Results Through Bug Fixes or Comments”.

Example - Non-initialized variable error

```
int get_sensor_value(void)
{
    extern int getsensor(void);
    int command;
    int val;

    command = getsensor();
    if (command == 2)
      {
        val = getsensor();
      }

    return val;
    /* Defect: val does not have a value if command is not 2 */
}
```

If `command` is not 2, the variable `val` is unassigned. In this case, the return value of function `get_sensor_value` is undetermined.

Correction — Initialize During Declaration

One possible correction is to initialize `val` during declaration so that the initialization is not bypassed on some execution paths.

```
int get_sensor_value(void)
{
    extern int getsensor(void);
    int command;
    /* Fix: Initialize val */
    int val=0;

    command = getsensor();
    if (command == 2)
      {
        val = getsensor();
      }

    return val;
 }
```

`val` is assigned an initial value of 0. When `command` is not equal to 2, the function `get_sensor_value` returns this value.

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [usrfmt]

Including tainted or out-of-domain input in a format string

Description

Rule Definition

Including tainted or out-of-domain input in a format string.

Examples

Undefined or unspecified critical behavior

Description

The issue occurs when a statement has possible undefined or implementation-defined behavior, for instance, use of a function-like macro with too many or too few arguments.

Tainted string format

Description

Tainted string format detects string formatting with `printf`-style functions that contain elements from unsecure sources.

Risk

If you use externally controlled elements to format a string, you can cause buffer overflow or data-representation problems. An attacker can use these string formatting elements to view the contents of a stack using `%x` or write to a stack using `%n`.

Fix

Pass a static string to format string functions. This fix ensures that an external actor cannot control the string.

Another possible fix is to allow only the expected number of arguments. If possible, use functions that do not support the vulnerable `%n` operator in format strings.

Example - Get Elements from User Input

```
#include "stdio.h"

void taintedstringformat(char* userstr) {
    printf(userstr);
}
```

This example prints the input argument `userstr`. The string is unknown. If it contains elements such as `%`, `printf` can interpret `userstr` as a string format instead of a string, causing your program to crash.

Correction — Print as String

One possible correction is to print `userstr` explicitly as a string so that there is no ambiguity.

```
#include "stdio.h"

void taintedstringformat(char* userstr) {
    printf("%.20s", userstr);
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [xfilepos]

Using a value for fsetpos other than a value returned from fgetpos

Description

Rule Definition

Using a value for fsetpos other than a value returned from fgetpos.

Examples

Invalid file position

Description

Invalid file position occurs when the file position argument of `fsetpos()` uses a value that is not obtained from `fgetpos()`.

Risk

The function `fgetpos(FILE *stream, fpos_t *pos)` gets the current file position of the stream. When you use any other value as the file position argument of `fsetpos(FILE *stream, const fpos_t *pos)`, you might access an unintended location in the stream.

Fix

Use the value returned from a successful call to `fgetpos()` as the file position argument of `fsetpos()`.

Example - `memset()` Sets File Position Argument

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
```

```
FILE *func(FILE *file)
{
    fpos_t offset;
    if (file == NULL)
    {
        /* Handle error */
    }
    /* Store initial position in variable 'offset' */
    (void)memset(&offset, 0, sizeof(offset));

    /* Read data from file */

    /* Return to the initial position. offset was not
    returned from a call to fgetpos()    */
    if (fsetpos(file, &offset) != 0)
    {
        /* Handle error */
    }
    return file;
}
```

In this example, `fsetpos()` uses `offset` as its file position argument. However, the value of `offset` is set by `memset()`. The preceding code might access the wrong location in the stream.

Correction — Use a File Position Returned From `fgetpos()`

Call `fgetpos()`, and if it returns successfully, use the position argument in your call to `fsetpos()`.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

FILE *func(FILE *file)
{
    fpos_t offset;
    if (file == NULL)
    {
        /* Handle error */
```

```
    }
    /* Store initial position in variable 'offset'
    using fgetpos() */
    if (fgetpos(file, &offset) != 0)
    {
        /* Handle error */
    }

    /* Read data from file */

    /* Back to the initial position */
    if (fsetpos(file, &offset) != 0)
    {
        /* Handle error */
    }
    return file;
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

ISO/IEC TS 17961 [xfree]

Reallocating or freeing memory that was not dynamically allocated

Description

Rule Definition

Reallocating or freeing memory that was not dynamically allocated.

Examples

Invalid free of pointer

Description

Invalid free of pointer occurs when a block of memory released using the `free` function was not previously allocated using `malloc`, `calloc`, or `realloc`.

Risk

The `free` function releases a block of memory allocated on the heap. If you try to access a location on the heap that you did not allocate previously, a segmentation fault can occur.

The issue can highlight coding errors. For instance, you perhaps wanted to use the `free` function or a previous `malloc` function on a different pointer.

Fix

In most cases, you can fix the issue by removing the `free` statement. If the pointer is not allocated memory from the heap with `malloc` or `calloc`, you do not need to free the pointer. You can simply reuse the pointer as required.

If the issue highlights a coding error such as use of `free` or `malloc` on the wrong pointer, correct the error.

If the issue occurs because you use the `free` function to free memory allocated with the `new` operator, replace the `free` function with the `delete` operator.

Example - Invalid Free of Pointer Error

```
#include <stdlib.h>

void Assign_Ones(void)
{
  int p[10];
  for(int i=0;i<10;i++)
     *(p+i)=1;

  free(p);
  /* Defect: p does not point to dynamically allocated memory */
}
```

The pointer `p` is deallocated using the `free` function. However, `p` points to a memory location that was not dynamically allocated.

Correction — Remove Pointer Deallocation

If the number of elements of the array `p` is known at compile time, one possible correction is to remove the deallocation of the pointer `p`.

```
#include <stdlib.h>

void Assign_Ones(void)
 {
  int p[10];
  for(int i=0;i<10;i++)
     *(p+i)=1;
  /* Fix: Remove deallocation of p */
 }
```

Correction — Introduce Pointer Allocation

If the number of elements of the array `p` is not known at compile time, one possible correction is to dynamically allocate memory to the array `p`.

```
#include <stdlib.h>

void Assign_Ones(int num)
{
```

```
  int *p;
  /* Fix: Allocate memory dynamically to p */
  p=(int*) calloc(10,sizeof(int));
  for(int i=0;i<10;i++)
     *(p+i)=1;
  free(p);
}
```

Check Information

Decidability: Undecidable

See Also

Introduced in R2019a

Custom Coding Rules

Group 1: Files

The custom rules 1.*x* in Polyspace enforce naming conventions for files and folders. For information on how to enable these rules, see .

Number	Rule Applied	Other details
1.1	All source file names must follow the specified pattern.	Only the base name is checked. A source file is a file that is not included.
1.2	All source folder names must follow the specified pattern.	Only the folder name is checked. A source file is a file that is not included.
1.3	All include file names must follow the specified pattern.	Only the base name is checked. An include file is a file that is included.
1.4	All include folder names must follow the specified pattern.	Only the folder name is checked. An include file is a file that is included.

Group 2: Preprocessing

The custom rules 2.*x* in Polyspace enforce naming conventions for macros. For information on how to enable these rules, see .

Number	Rule Applied	Other details
2.1	All macros must follow the specified pattern.	Macro names are checked before preprocessing.
2.2	All macro parameters must follow the specified pattern.	Macro parameters are checked before preprocessing.

Group 3: Type definitions

The custom rules 3.*x* in Polyspace enforce naming conventions for fundamental data types. For information on how to enable these rules, see .

Number	Rule Applied	Other details
3.1	All integer types must follow the specified pattern.	Applies to integer types specified by `typedef` statements. Does not apply to enumeration types. For example: `typedef signed int int32_t;`
3.2	All float types must follow the specified pattern.	Applies to float types specified by `typedef` statements. For example: `typedef float f32_t;`
3.3	All pointer types must follow the specified pattern.	Applies to pointer types specified by `typedef` statements. For example: `typedef int* p_int;`
3.4	All array types must follow the specified pattern.	Applies to array types specified by `typedef` statements. For example: `typedef int[3] a_int_3;`
3.5	All function pointer types must follow the specified pattern.	Applies to function pointer types specified by `typedef` statements. For example: `typedef void (*pf_callback) (int);`

Group 4: Structures

The custom rules 4.*x* in Polyspace enforce naming conventions for structured data types. For information on how to enable these rules, see .

Number	Rule Applied	Other details
4.1	All `struct` tags must follow the specified pattern.	
4.2	All `struct` types must follow the specified pattern.	`struct` types are aliases for previously defined structures (defined with the `typedef` or `using` keyword).
4.3	All `struct` fields must follow the specified pattern.	
4.4	All `struct` bit fields must follow the specified pattern.	

Group 5: Classes (C++)

The custom rules 5.*x* in Polyspace enforce naming conventions for classes and class members. For information on how to enable these rules, see .

Number	Rule Applied	Other details
5.1	All class names must follow the specified pattern.	
5.2	All class types must follow the specified pattern.	Class types are aliases for previously defined classes (defined with the `typedef` or `using` keyword).
5.3	All data members must follow the specified pattern.	
5.4	All function members must follow the specified pattern.	
5.5	All static data members must follow the specified pattern.	
5.6	All static function members must follow the specified pattern.	
5.7	All bitfield members must follow the specified pattern.	

Group 6: Enumerations

The custom rules 6.*x* in Polyspace enforce naming conventions for enumerations. For information on how to enable these rules, see .

Number	Rule Applied	Other details
6.1	All enumeration tags must follow the specified pattern.	
6.2	All enumeration types must follow the specified pattern.	Enumeration types are aliases for previously defined enumerations (defined with the `typedef` or `using` keyword).
6.3	All enumeration constants must follow the specified pattern.	

Group 7: Functions

The custom rules 7.*x* in Polyspace enforce naming conventions for functions and function parameters. For information on how to enable these rules, see .

Number	Rule Applied	Other details
7.1	All global functions must follow the specified pattern.	A global function is a function with external linkage.
7.2	All static functions must follow the specified pattern.	A static function is a function with internal linkage.
7.3	All function parameters must follow the specified pattern.	In C++, applies to non-member functions.

Group 8: Constants

The custom rules 8.*x* in Polyspace enforce naming conventions for constants. For information on how to enable these rules, see .

Number	Rule Applied	Other details
8.1	All global constants must follow the specified pattern.	A global constant is a constant with external linkage.
8.2	All static constants must follow the specified pattern.	A static constant is a constant with internal linkage.
8.3	All local constants must follow the specified pattern.	A local constant is a constant without linkage.
8.4	All static local constants must follow the specified pattern.	A static local constant is a constant declared static in a function.

Group 9: Variables

The custom rules 9.*x* in Polyspace enforce naming conventions for variables. For information on how to enable these rules, see .

Number	Rule Applied	Other details
9.1	All global variables must follow the specified pattern.	A global variable is a variable with external linkage.
9.2	All static variables must follow the specified pattern.	A static variable is a variable with internal linkage.
9.3	All local variables must follow the specified pattern.	A local variable is a variable without linkage.
9.4	All static local variables must follow the specified pattern.	A static local variable is a variable declared static in a function.

Group 10: Name spaces (C++)

The custom rules 10.*x* in Polyspace enforce naming conventions for namespaces. For information on how to enable these rules, see .

Number	Rule Applied
10.1	All names spaces must follow the specified pattern.

Group 11: Class templates (C++)

The custom rules 11.*x* in Polyspace enforce naming conventions for class templates. For information on how to enable these rules, see .

Number	Rule Applied	Other details
11.1	All class templates must follow the specified pattern.	
11.2	All class template parameters must follow the specified pattern.	

Group 12: Function templates (C++)

The custom rules 12.*x* in Polyspace enforce naming conventions for function templates. For information on how to enable these rules, see .

Number	Rule Applied	Other details
12.1	All function templates must follow the specified pattern.	Applies to non-member functions.
12.2	All function template parameters must follow the specified pattern.	Applies to non-member functions.
12.3	All function template members must follow the specified pattern.	

Group 20: Style

The custom rules 20.*x* in Polyspace enforce coding style conventions such as number of characters per line. For information on how to enable these rules, see .

Number	Rule Applied	Other details
20.1	Source line length must not exceed specified number of characters.	When configuring the checker, specify: • A number for the character limit. Use the **Pattern** column on the configuration or the `pattern=` line in the custom rules text file. • A violation message such as: `Line exceeds` *`n`* `characters.` Use the **Convention** column on the configuration or the `convention=` line in the custom rules text file.

9

Code Metrics

Comment Density

Ratio of number of comments to number of statements

Description

The metric specifies the ratio of comments to statements expressed as a percentage.

Based on HIS specifications:

- Multi-line comments count as one comment.

  For instance, the following constitutes one comment:

  ```
  // This function implements
  // regular maintenance on an internal database
  ```

- Comments that start with the source code line do not count as comments.

  For instance, this comment does not count as a comment for the metric but counts as a statement instead:

  ```
  remove(i); // Remove employee record
  ```

- A statement typically ends with a semi-colon with some exceptions. Exceptions include semi-colons in `for` loops or structure field declarations.

  For instance, the initialization, condition and increment within parentheses in a `for` loop is counted as one statement. The following counts as one statement:

  ```
  for(i=0; i <100; i++)
  ```

  If you also declare the loop counter at initialization, it counts as two statements.

The recommended lower limit for this metric is 20. For better readability of your code, try to place at least one comment for every five statements.

Examples

Comment Density Calculation

```
struct record {
    char name[40];
    long double salary;
    int isEmployed;
};

struct record dataBase[100];

struct record fetch(void);
void remove(int);

void maintenanceRoutines() {
// This function implements
// regular maintenance on an internal database
    int i;
    struct record tempRecord;

    for(i=0; i <100; i++) {
        tempRecord = fetch(); // This function fetches a record
        // from the database
        if(tempRecord.isEmployed == 0)
            remove(i);         // Remove employee record
        //from the database
    }
}
```

In this example, the comment density is 38. The calculation is done as follows:

Code	Running Total of Comments	Running Total of Statements

`struct record {`
`  char name[40];`
`  long double salary;`
`  int isEmployed;`
`};`
	0	1

Code	Running Total of Comments	Running Total of Statements

`struct record dataBase[100];`
`struct record fetch(void);`
`void remove(int);`
	0	4

`void maintenanceRoutines() {`	0	4
`// This function implements` `// regular maintenance on an internal database`	1	4
`int i;` `struct record tempRecord;`	1	6
`for(i=0; i <100; i++) {`	1	6

`tempRecord = fetch(); // This`
`function fetches a record`
`// from the database`
	2	7

`if(tempRecord.isEmployed == 0)`
`remove(i);`
`// Remove employee record`
`//from the database`
`}`
`}`
	3	8

There are 3 comments and 8 statements. The comment density is 3/8*100 = 38.

Metric Information

Group: File
Acronym: COMF

See Also

Cyclomatic Complexity

Number of linearly independent paths in function body

Description

This metric calculates the number of decision points in a function and adds one to the total. A decision point is a statement that causes your program to branch into two paths.

The recommended upper limit for this metric is 10. If the cyclomatic complexity is high, the code is both difficult to read and can cause more orange checks. Therefore, try to limit the value of this metric.

Computation Details

The metric calculation uses the following rules to identify decision points:

- An `if` statement is one decision point.
- The statements `for` and `while` count as one decision point, even when no condition is evaluated, for example, in infinite loops.
- Boolean combinations `(&&, ||)` do not count as decision points.
- `case` statements do not count as decision points unless they are followed by a `break` statement. For instance, this code has a cyclomatic complexity of two:

```
switch(num) {
        case 0:
        case 1:
        case 2:
            break;
        case 3:
        case 4:
    }
```

- The calculation is done after preprocessing:
  - Macros are expanded.

- Conditional compilation is applied. The blocks hidden by preprocessing directives are ignored.

Examples

Function with Nested `if` Statements

```
int foo(int x,int y)
{
    int flag;
    if (x <= 0)
        /* Decision point 1*/
        flag = 1;
    else
    {
        if (x < y )
            /* Decision point 2*/
            flag = 1;
        else if (x==y)
            /* Decision point 3*/
            flag = 0;
        else
            flag = -1;
    }
    return flag;
}
```

In this example, the cyclomatic complexity of `foo` is 4.

Function with ? Operator

```
int foo (int x, int y) {
    if((x <0) ||(y < 0))
        /* Decision point 1*/
        return 0;
    else
        return (x > y ? x: y);
        /* Decision point 2*/
}
```

In this example, the cyclomatic complexity of `foo` is 3. The `?` operator is the second decision point.

Function with `switch` Statement

```
#include <stdio.h>

int foo(int x,int y, int ch)
{
    int val = 0;
    switch(ch) {
    case 1:
        /* Decision point 1*/
        val = x + y;
        break;
    case 2:
        /* Decision point 2*/
        val = x - y;
        break;
    default:
        printf("Invalid choice.");
    }
    return val;
}
```

In this example, the cyclomatic complexity of `foo` is 3.

Function with Nesting of Different Control-Flow Statements

```
int foo(int x,int y, int bound)
{
    int count = 0;
    if (x <= y)
        /* Decision point 1*/
        count = 1;
    else
        while(x>y) {
            /* Decision point 2*/
            x--;
            if(count< bound) {
                /* Decision point 3*/
                count++;
            }
        }
    return count;
}
```

In this example, the cyclomatic complexity of `foo` is 4.

Metric Information

Group: Function
Acronym: VG

See Also

Estimated Function Coupling

Measure of complexity between levels of call tree

Description

This metric provides an approximate measure of complexity between different levels of the call tree. The metric is defined as:

number of call occurrences – number of function definitions + 1

If there are more function definitions than function calls, the estimated function coupling result is negative.

This metric:

- Counts function calls and function definitions in the current file only.

  It does not count function definitions in a header file included in the current file.
- Treats `static` and `inline` functions like any other function.

Examples

Same Function Called Multiple Times

```
void checkBounds(int *);
int getUnboundedValue();

int getBoundedValue(void) {
    int num = getUnboundedValue();
    checkBounds(&num);
    return num;
}

void main() {
    int input1=getBoundedValue(), input2= getBoundedValue(), prod;
    prod = input1 * input2;
```

```
    checkBounds(&prod);
}
```

In this example, there are:

- 5 call occurrences. Both `getBoundedValue` and `checkBounds` are called twice and `getUnboundedValue` is called once.
- 2 function definitions. `main` and `getBoundedValue` are defined.

Therefore, the Estimated function coupling is `5 - 2 + 1 = 4`.

Negative Estimated Function Coupling

```
int foobar(int a, int b){
    return a+b;
}

int bar(int b){
    return b+2;
}

int foo(int a){
    return a<<2;
}

int main(int x){
    foobar(x,x+2);
    return 0;
}
```

This example shows how you can get a negative estimated function coupling result. In this example, you see:

- 1 function call in `main`.
- 4 defined functions: `foobar`, `bar`, `foo`, and `main`.

Therefore, the estimated function coupling is `1 - 4 + 1 = -2`.

Metric Information

Group: File

Acronym: FCO

See Also

Higher Estimate of Local Variable Size

Total size of all local variables in function

Description

This metric provides a conservative estimate of the total size of local variables in a function. The metric is the sum of the following sizes in bytes:

- Size of function return value
- Sizes of function parameters
- Sizes of local variables
- Additional padding introduced for memory alignment

Your actual stack usage due to local variables can be different from the metric value.

- Some of the variables are stored in registers instead of on the stack.
- Your compiler performs variable liveness analysis to enable certain memory optimizations. For instance, compilers store the address to which the execution returns following the function call. When computing this metric, Polyspace does not consider these optimizations.
- Your compiler uses additional memory during a function call. When computing this metric, Polyspace does not consider this hidden memory usage.

However, the metric provides a reasonable estimate of the stack usage due to local variables.

To determine the sizes of basic types, the software uses your specifications for `Target processor type (-target)`. The metric also takes into account `#pragma pack` directives in your code. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

All Variables of Same Type

```
int flag();

int func(int param) {
  int var_1;
  int var_2;
  if (flag()) {
      int var_3;
      int var_4;
    } else {
      int var_5;
    }
}
```

In this example, assuming 4 bytes for `int`, the higher estimate of local variable size is 28. The breakup of the size is shown in this table.

Variable	Size (in Bytes)	Running Total
Return value	4	4
Parameter `param`	4	8
Local variables `var_1` and `var_2`	4+4=8	16
Local variables defined in the `if` condition	(4+4)+4=12 The size of variables in the first branch is eight bytes. The size in the second branch is four bytes. The sum of the two branches is 12 bytes.	28

No padding is introduced for memory alignment because all the variables involved have the same type.

Variables of Different Types

```
char func(char param) {
  int var_1;
  char var_2;
  double var_3;
}
```

In this example, assuming one byte for `char`, four bytes for `int` and eight bytes for `double` and four bytes for alignment, the higher estimate of local variable size is 20. The alignment is usually the word size on your platform. In your Polyspace project, you specify the alignment through your target processor. For more information, see the Alignment column in `Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

The breakup of the size is shown in this table.

Variable	Size (in Bytes)	Running Total
Return value	1	1
Additional padding introduced before `param` is stored	0 No memory alignment is required because the next variable `param` has the same size.	1
Parameter `param`	1	2
Additional padding introduced before `var_1` is stored	2 Memory must be aligned using padding because the next variable `var_1` requires four bytes. The storage must start from a memory address at a multiple of four.	4
`var_1`	4	8

Variable	Size (in Bytes)	Running Total
Additional padding introduced before `var_2` is stored	0 No memory alignment is required because the next variable `var_2` has smaller size.	8
`var_2`	1	9
Additional padding introduced before `var_3` is stored	3 Memory must be aligned using padding because the next variable `var_3` has eight bytes. The storage must start from a memory address at a multiple of the alignment, four bytes.	12
`var_3`	8	20

The rules for the amount of padding are:

- If the next variable stored has the same or smaller size, no padding is required.
- If the next variable has a greater size:
  - If the variable size is the same as or less than the alignment on the platform, the amount of padding must be sufficient so that the storage address is a multiple of its size.
  - If the variable size is greater than the alignment on the platform, the amount of padding must be sufficient so that the storage address is a multiple of the alignment.

C++ Methods and Objects

```
class MySimpleClass {
  public:
    MySimpleClass() {};
    MySimpleClass(int) {};
    ~MySimpleClass() {};
};
```

```
int main() {
  MySimpleClass c;
  return 0;
}
```

In this example, the estimated local variable sizes are:

- Constructor `MySimpleClass::MySimpleClass()`: Four bytes.

  The size comes from the `this` pointer, which is an implicit argument to the constructor. You specify the pointer size using the option `Target processor type (-target)`.
- Constructor `MySimpleClass::MySimpleClass(int)`: Eight bytes.

  The size comes from the `this` pointer and the `int` argument.
- Destructor `MySimpleClass::~MySimpleClass()`: Four bytes.

  The size comes from the `this` pointer.
- `main()`: Five bytes.

  The size comes from the `int` return value and the size of object `c`. The minimum size of an object is the alignment that you specify using the option `Target processor type (-target)`.

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

C++ Functions with Object Arguments

```
class MyClass {
  public:
    MyClass() {};
    MyClass(int) {};
    ~MyClass() {};
  private:
    int i[10];
};
void func1(const MyClass& c) {
}

void func2() {
```

```
  func1(4);
}
```

In this example, the estimated local variable size for `func2()` is 40 bytes. When `func2()` calls `func1()`, a temporary object of the class `MyClass` is created. The object has ten `int` variables, each with a size of four bytes.

Metric Information

Group: Function
Acronym: `LOCAL_VARS_MAX`

See Also

Introduced in R2016b

Language Scope

Language scope

Description

This metric measures the cost of maintaining or changing a function. It is calculated as:

```
(N1 + N2)/(n1 + n2)
```

Here:

- `N1` is the number of occurrences of operators.

  Other than identifiers (variable or function names) and literal constants, everything else counts as operators.
- `N2` is the number of occurrences of operands.
- `n1` is the number of distinct operators.
- `n2` is the number of distinct operands.

  The metric considers a literal constant with a suffix as different from the constant without the suffix. For instance, 0 and `0U` are considered different.

Tip To find `N1 + N2`, count the total number of tokens. To find `n1 + n2`, count the number of unique tokens.

The recommended upper limit for this metric is 4. For lower maintenance cost for a function, try to enforce an upper limit on this metric. For instance, if the same operand occurs many times, to change the operand name, you have to make many substitutions.

Examples

Language Scope Calculation

```
int f(int i)
{
```

```
    if (i == 1)
        return i;
    else
        return i * g(i-1);
}
```

In this example:

- `N1` = 19.
- `N2` = 9.
- `n1` = 12.

  The distinct operators are `int`, `(`, `)`, `{`, `if`, `==`, `return`, `else`, `*`, `-`, `;`, `}`.
- `n2` = 4.

  The distinct operands are `f`, `i`, `1` and `g`.

The language scope of `f` is (17 + 9) / (12 + 4) = 1.8.

C++ Namespaces in Language Scope Calculation

```
namespace std {
  int func2() {
    return 123;
  }
};

namespace my_namespace {
  using namespace std;
  int func1(int a, int b) {
    return func2();
  }
};
```

In this example, the namespace `std` is implicitly associated with `func2`. The language scope computation treats `func2()` as `std::func2()`. Likewise, the computation treats `func1()` as `my_namespace::func1()`.

For instance, the language scope value for `func1` is 1.3. To break down this calculation:

- `N1 + N2` = 20.

- `n1 + n2` = 15.

  The distinct operators are `int`, `::`, `(`, comma, `)`, `{`, `return`, `;`, and `}`.

  The distinct operands are `my_namespace`, `func1`, `a`, `b`, `std`, and `func2`.

Metric Information

Group: Function
Acronym: `VOCF`

See Also

Lower Estimate of Local Variable Size

Total size of local variables in function taking nested scopes into account

Description

This metric provides an optimistic estimate of the total size of local variables in a function. The metric is the sum of the following sizes in bytes:

- Size of function return value
- Sizes of function parameters
- Sizes of local variables

  Suppose that the function has variable definitions in nested scopes as follows:

```
type func (type param_1, ...) {

  {
    /* Scope 1 */
    type var_1, ...;
  }
  {
    /* Scope 2 */
    type var_2, ...;
  }
}
```

  The software computes the total variable size in each scope and uses whichever total is greatest. For instance, if a conditional statement has variable definitions, the software computes the total variable size in each branch, and then uses whichever total is greatest. If a nested scope itself has further nested scopes, the same process is repeated for the inner scopes.

  A variable defined in a nested scope is not visible outside the scope. Therefore, some compilers reuse stack space for variables defined in separate scopes. This metric provides a more accurate estimate of stack usage for such compilers. Otherwise, use the metric `Higher Estimate of Local Variable Size`. This metric adds the size of all local variables, whether or not they are defined in nested scopes.

- Additional padding introduced for memory alignment

Your actual stack usage due to local variables can be different from the metric value.

- Some of the variables are stored in registers instead of on the stack.
- Your compiler performs variable liveness analysis to enable certain memory optimizations. When computing this metric, Polyspace does not consider these optimizations.
- Your compiler uses additional memory during a function call. For instance, compilers store the address to which the execution returns following the function call. When computing this metric, Polyspace does not consider this hidden memory usage.

However, the metric provides a reasonable estimate of the stack usage due to local variables.

To determine the sizes of basic types, the software uses your specifications for `Target processor type (-target)`. The metric also takes into account `#pragma pack` directives in your code. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

All Variables of Same Type

```
int flag();

int func(int param) {
  int var_1;
  int var_2;
  if (flag()) {
      int var_3;
      int var_4;
    } else {
      int var_5;
    }
}
```

In this example, assuming four bytes for `int`, the lower estimate of local variable size is 24. The breakup of the metric is shown in this table.

Variable	Size (in Bytes)	Running Total
Return value	4	4
Parameter `param`	4	8
Local variables `var_1` and `var_2`	`4+4=8`	16
Local variables defined in the `if` condition	`max(4+4,4)= 8` The size of variables in the first branch is eight bytes. The size in the second branch is four bytes. The maximum of the two branches is eight bytes.	24

No padding is introduced for memory alignment because all the variables involved have the same type.

Variables of Different Types

```
char func(char param) {
  int var_1;
  char var_2;
  double var_3;
}
```

In this example, assuming one byte for `char`, four bytes for `int`, eight bytes for `double` and four bytes for alignment, the lower estimate of local variable size is 20. The alignment is usually the word size on your platform. In your Polyspace project, you specify the alignment through your target processor. For more information, see the Alignment column in `Target processor type (-target)Target processor type (-target)`. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

The breakup of the size is shown in this table.

Variable	Size (in Bytes)	Running Total
Return value	1	1

Variable	Size (in Bytes)	Running Total
Additional padding introduced before `param` is stored	0 No memory alignment is required because the next variable `param` has the same size.	1
Parameter `param`	1	2
Additional padding introduced before `var_1` is stored	2 Memory must be aligned using padding because the next variable `var_1` requires four bytes. The storage must start from a memory address at a multiple of four.	4
`var_1`	4	8
Additional padding introduced before `var_2` is stored	0 No memory alignment is required because the next variable `var_2` has smaller size.	8
`var_2`	1	9
Additional padding introduced before `var_3` is stored	3 Memory must be aligned using padding because the next variable `var_3` requires eight bytes. The storage must start from a memory address at a multiple of the alignment, four bytes.	12
`var_3`	8	20

The rules for the amount of padding are:

- If the next variable stored has the same or smaller size, no padding is required.
- If the next variable has a greater size:
  - If the variable size is the same as or less than the alignment on the platform, the amount of padding must be sufficient so that the storage address is a multiple of its size.
  - If the variable size is greater than the alignment on the platform, the amount of padding must be sufficient so that the storage address is a multiple of the alignment.

C++ Methods and Objects

```
class MySimpleClass {
  public:
    MySimpleClass() {};
    MySimpleClass(int) {};
    ~MySimpleClass() {};
};

int main() {
  MySimpleClass c;
  return 0;
}
```

In this example, the estimated local variable sizes are:

- Constructor `MySimpleClass::MySimpleClass()`: Four bytes.

  The size comes from the `this` pointer, which is an implicit argument to the constructor. You specify the pointer size using the option `Target processor type (-target)`.
- Constructor `MySimpleClass::MySimpleClass(int)`: Eight bytes.

  The size comes from the `this` pointer and the `int` argument.
- Destructor `MySimpleClass::~MySimpleClass()`: Four bytes.

  The size comes from the `this` pointer.
- `main()`: Five bytes.

The size comes from the `int` return value and the size of object `c`. The minimum size of an object is the alignment that you specify using the option `Target processor type (-target)`.

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

C++ Functions with Object Arguments

```
class MyClass {
  public:
    MyClass() {};
    MyClass(int) {};
    ~MyClass() {};
  private:
    int i[10];
};
void func1(const MyClass& c) {
}

void func2() {
  func1(4);
}
```

In this example, the estimated local variable size for `func2()` is 40 bytes. When `func2()` calls `func1()`, a temporary object of the class `MyClass` is created. The object has ten `int` variables, each with a size of four bytes.

Metric Information

Group: Function
Acronym: `LOCAL_VARS_MIN`

See Also

Introduced in R2016b

Maximum Stack Usage

Total size of local variables in function plus maximum stack usage from callees

Description

This metric provides a conservative estimate of the stack usage by a function. The metric is the sum of these sizes in bytes:

-
- Maximum value from the stack usages of the function callees. The computation uses the maximum stack usage of each callee.

  For instance, in this example, the maximum stack usage of `func` is the same as the maximum stack usage of `func1` or `func2`, *whichever is greater*.

  ```
  void func(void) {
      func1();
      func2();
  }
  ```

  If the function calls are in different branches of a conditional statement, this metric considers the branch with the greatest stack usage.

  The analysis does the stack size estimation later on when it has resolved which function calls actually occur. For instance, if a function call occurs in unreachable code, the stack size does not take the call into account. The analysis can also take into account calls through function pointers.

Your actual stack usage can be different from the metric value.

- Some of the variables are stored in registers instead of on the stack.
- Your compiler performs variable liveness analysis to enable certain memory optimizations. When estimating this metric, Polyspace does not consider these optimizations.
- Your compiler uses additional memory during a function call. For instance, compilers store the address to which the execution returns following the function call. When estimating this metric, Polyspace does not consider this hidden memory usage.

However, the metric provides a reasonable estimate of the stack usage.

To determine the sizes of basic types, the software uses your specifications for `Target processor type (-target)`. The metric takes into account `#pragma pack` directives in your code. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Function with One Callee

```
double func(int);
double func2(int);

double func(int status) {
    double res = func2(status);
    return res;
}

double func2(int status) {
    double res;
    if(status == 0) {
      int temp;
      res = 0.0;
    }
    else {
      double temp;
      res = 1.0;
    }
    return res;
}
```

In this example, assuming four bytes for `int` and eight bytes for `double`, the maximum stack usages are:

- `func2`: 32 bytes

  This value includes the sizes of its parameter (4 bytes), local variable `res` (8 bytes), local variable `temp` counted twice (4+8=12 bytes), and return value (8 bytes).

  The metric does not take into account that the first `temp` is no longer live when the second `temp` is defined.

- `func`: 52 bytes

  This value includes the sizes of its parameter, local variable `res`, and return value, a total of 20 bytes. This value includes the 32 bytes of maximum stack usage by its callee, `func2`.

Function with Multiple Callees

```
void func1(int);
void func2(void);


void func(int status) {
    func1(status);
    func2();
}

void func1(int status) {
    if(status == 0) {
      int val;
    }
    else {
      double val2;
    }
}

void func2(void) {
    double val;
}
```

In this example, assuming four bytes for `int` and eight bytes for `double`, the maximum stack usages are:

- `func1`: 16 bytes

  This value includes the sizes of its parameter (4 bytes) and local variable `temp` counted twice (4+8=12 bytes).
- `func2`: 8 bytes
- `func`: 20 bytes

  This value includes the sizes of its parameter (4 bytes) and the maximum of stack usages of `func1` and `func2` (16 bytes).

Function with Multiple Callees in Different Branches

```
void func1(void);
void func2(void);


void func(int status) {
    if(status==0)
        func1();
    else
        func2();
}

void func1(void) {
    double val;
}

void func2(void) {
    int val;
}
```

In this example, assuming four bytes for `int` and eight bytes for `double`, the maximum stack usages are:

- `func1`: 8 bytes
- `func2`: 4 bytes
- `func`: 12 bytes

  This value includes the sizes of its parameter (4 bytes) and the maximum stack usage from the two branches (8 bytes).

Functions with Variable Number of Parameters (Variadic Functions)

```
#include <stdarg.h>

void fun_vararg(int x, ...) {
  va_list ap;
  va_start(ap, x);
  int i;
  for (i=0; i<x; i++) {
    int j = va_arg(ap, int);
```

```
  }
  va_end(ap);
}


void call_fun_vararg1(void) {
  long long int l = 0;
  fun_vararg(3, 4, 5, 6, l);
}


void call_fun_vararg2(void) {
  fun_vararg(1,0);
}
```

In this function, `fun_vararg` is a function with variable number of parameters. The maximum stack usage of `fun_vararg` takes into account the call to `fun_vararg` with the maximum number of arguments. The call with the maximum number of arguments is the call in `call_fun_vararg1` with five arguments (one for the fixed parameter and four for the variable parameters). The maximum stack usages are:

- `fun_vararg`: 36 bytes.

  This value takes into account:

  - The size of the fixed parameter `x` (4 bytes).
  - The sizes of the variable parameters from the call with the maximum number of parameters. In that call, there are four variable arguments: three `int` and one `long long int` variable (3 times 4 + 1 times 8 = 20 bytes).
  - The sizes of the local variables `i`, `j` and `ap` (12 bytes). The size of the `va_list` variable uses the pointer size defined in the target (in this case, 4 bytes).
- `call_fun_vararg1`: 44 bytes.

  This value takes into account:

  - The stack size usage of `fun_vararg` with five arguments (36 bytes).
  - The size of local variable `l` (8 bytes).
- `call_fun_vararg2`: 20 bytes.

  Since `call_fun_vararg2` has no local variables, this value is the same as the stack size usage of `fun_vararg` with two arguments (20 bytes, of which 12 bytes are for the local variables and 8 bytes are for the two parameters of `fun_vararg`).

Metric Information

Group: Function
Acronym: MAX_STACK

See Also

Introduced in R2017b

Minimum Stack Usage

Total size of local variables in function taking nested scopes into account plus maximum stack usage from callees

Description

This metric provides an optimistic estimate of the stack usage by a function. Unlike the metric , this metric takes nested scopes into account. For instance, if variables are defined in two mutually exclusive branches of a conditional statement, the metric considers that the stack space allocated to the variables in one branch can be reused in the other branch.

The metric is the sum of these sizes in bytes:

- .
- Maximum value from the stack usages of the function callees. The computation uses the minimum stack usage of each callee.

  For instance, in this example, the minimum stack usage of `func` is the same as the minimum stack usage of `func1` or `func2`, *whichever is greater*.

  ```
  void func(void) {
      func1();
      func2();
  }
  ```

  If the function calls are in different branches of a conditional statement, this metric considers the branch with the least stack usage.

  The analysis does the stack size estimation later on when it has resolved which function calls actually occur. For instance, if a function call occurs in unreachable code, the stack size does not take the call into account. The analysis can also take into account calls through function pointers.

Your actual stack usage can be different from the metric value.

- Some of the variables are stored in registers instead of on the stack.

- Your compiler performs variable liveness analysis to enable certain memory optimizations. When estimating this metric, Polyspace does not consider these optimizations.
- Your compiler uses additional memory during a function call. For instance, compilers store the address to which the execution returns following the function call. When estimating this metric, Polyspace does not consider this hidden memory usage.

However, the metric provides a reasonable estimate of the stack usage.

To determine the sizes of basic types, the software uses your specifications for `Target processor type (-target)`. The metric takes into account `#pragma pack` directives in your code. For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Examples

Function with One Callee

```
double func2(int);

double func(int status) {
    double res = func2(status);
    return res;
}

double func2(int status) {
    double res;
    if(status == 0) {
      int temp;
      res = 0.0;
    }
    else {
      double temp;
      res = 1.0;
    }
    return res;
}
```

In this example, assuming four bytes for `int` and eight bytes for `double`, the maximum stack usages are:

- `func2`: 28 bytes

  This value includes the sizes of its parameter (4 bytes), local variable `res` (8 bytes), one of the two local variables `temp` (8 bytes), and return value (8 bytes).

  The metric takes into account that the first `temp` is no longer live when the second `temp` is defined. It uses the variable `temp` with data type `double` because its size is greater.

- `func`: 48 bytes

  This value includes the sizes of its parameter, local variable `res`, and return value, a total of 20 bytes. This value includes the 28 bytes of minimum stack usage by its callee, `func2`.

Function with Multiple Callees

```
void func1(int);
void func2(void);


void func(int status) {
    func1(status);
    func2();
}

void func1(int status) {
    if(status == 0) {
      int val;
    }
    else {
      double val2;
    }
}

void func2(void) {
    double val;
}
```

In this example, assuming four bytes for `int` and eight bytes for `double`, the maximum stack usages are:

- `func1`: 12 bytes

This value includes the sizes of its parameter (4 bytes) and one of the two local variables `temp` (8 bytes). The metric takes into account that the first `temp` is no longer live when the second `temp` is defined.

- `func2`: 8 bytes
- `func`: 16 bytes

  This value includes the sizes of its parameter (4 bytes) and the maximum of stack usages of `func1` and `func2` (12 bytes).

Function with Multiple Callees in Different Branches

```
void func1(void);
void func2(void);


void func(int status) {
    if(status==0)
        func1();
    else
        func2();
}

void func1(void) {
    double val;
}

void func2(void) {
    int val;
}
```

In this example, assuming four bytes for `int` and eight bytes for `double`, the maximum stack usages are:

- `func1`: 8 bytes
- `func2`: 4 bytes
- `func`: 8 bytes

  This value includes the sizes of its parameter (4 bytes) and the minimum stack usage from the two branches (4 bytes).

Functions with Variable Number of Parameters (Variadic Functions)

```
#include <stdarg.h>

void fun_vararg(int x, ...) {
  va_list ap;
  va_start(ap, x);
  int i;
  for (i=0; i<x; i++) {
    int j = va_arg(ap, int);
  }
  va_end(ap);
}


void call_fun_vararg1(void) {
  long long int l = 0;
  fun_vararg(3, 4, 5, 6, l);
}


void call_fun_vararg2(void) {
  fun_vararg(1,0);
}
```

In this function, `fun_vararg` is a function with variable number of parameters. The minimum stack usage of `fun_vararg` takes into account the call to `fun_vararg` with the minimum number of arguments. The call with the minimum number of arguments is the call in `call_fun_vararg2` with two arguments (one for the fixed parameter and one for the variable parameter). The minimum stack usages are:

- `fun_vararg`: 20 bytes.

  This value takes into account:

  - The size of the fixed parameter `x` (4 bytes).
  - The sizes of the variable parameters from the call with the minimum number of parameters. In that call, there is only one variable argument of type `int` (4 bytes).
  - The sizes of the local variables `i`, `j` and `ap` (12 bytes). The size of the `va_list` variable uses the pointer size defined in the target (in this case, 4 bytes).

- `call_fun_vararg1`: 44 bytes.

  This value takes into account:

  - The stack size usage of `fun_vararg` with five arguments (36 bytes, of which 12 bytes are for the local variable sizes and 20 bytes are for the fixed and variable parameters of `fun_vararg`).
  - The size of local variable `l` (8 bytes).
- `call_fun_vararg2`: 20 bytes.

  Since `call_fun_vararg2` has no local variables, this value is the same as the stack size usage of `fun_vararg` with two arguments (20 bytes).

Metric Information

Group: Function
Acronym: `MIN_STACK`

See Also

Introduced in R2017b

Number of Call Levels

Maximum depth of nesting of control flow structures

Description

This metric specifies the maximum nesting depth of control flow statements such as `if`, `switch`, `for`, or `while` in a function. A function without control-flow statements has a call level 1.

The recommended upper limit for this metric is 4. For better readability of your code, try to enforce an upper limit for this metric.

Examples

Function with Nested `if` Statements

```
int foo(int x,int y)
{
    int flag = 0;
    if (x <= 0)
        /* Call level 1*/
        flag = 1;
    else
    {
        if (x <= y )
            /* Call level 2*/
            flag = 1;
        else
            flag = -1;
    }
    return flag;
}
```

In this example, the number of call levels of `foo` is 2.

Function with Nesting of Different Control-Flow Statements

```
int foo(int x,int y, int bound)
{
    int count = 0;
    if (x <= y)
        /* Call level 1*/
        count = 1;
    else
        while(x>y) {
            /* Call level 2*/
            x--;
            if(count< bound) {
                /* Call level 3*/
                count++;
            }
        }
    return count;
}
```

In this example, the number of call levels of `foo` is 3.

Metric Information

Group: Function
Acronym: LEVEL

See Also

Number of Call Occurrences

Number of calls in function body

Description

This metric specifies the number of function calls in the body of a function.

Calls through a function pointer are not counted. Calls in unreachable code and calls to standard library functions are counted. `assert` is considered as a macro and not a function, so it is not counted.

Examples

Same Function Called Multiple Times

```
int func1(void);
int func2(void);

int foo() {
    return (func1() + func1()*func1() + 2*func2());
}
```

In this example, the number of call occurrences in `foo` is 4.

Function Called in a Loop

```
#include<stdio.h>

void fillArraySize10(int *arr) {
    for(int i=0; i<10; i++)
        arr[i]=getVal();
}

int getVal(void) {
    int val;
    printf("Enter a value:");
```

```
    scanf("%d", &val);
    return val;
}
```

In this example, the number of call occurrences in `fillArraySize10` is 1.

Recursive Function

```
#include <stdio.h>

void main() {
 int count;
 printf("How many numbers ?");
 scanf("%d",&count);
 fibonacci(count);
}

int fibonacci(int num)
{
   if ( num == 0 )
      return 0;
   else if ( num == 1 )
      return 1;
   else
      return ( fibonacci(num-1) + fibonacci(num-2) );
}
```

In this example, the number of call occurrences in `fibonacci` is 2.

Metric Information

Group: Function
Acronym: NCALLS

See Also

Number of Called Functions

Number of callees of a function

Description

This metric specifies the number of callees of a function.

Calls through a function pointer are not counted. Calls in unreachable code and calls to standard library functions are counted. `assert` is considered as a macro and not a function, so it is not counted.

The recommended upper limit for this metric is 7. For more self-contained code, try to enforce an upper limit on this metric.

Examples

Same Function Called Multiple Times

```
int func1(void);
int func2(void);

int foo() {
    return (func1() + func1()*func1() + 2*func2());
}
```

In this example, the number of called functions in `foo` is 2. The called functions are `func1` and `func2`.

Recursive Function

```
#include <stdio.h>

void main() {
 int count;
 printf("How many numbers ?");
 scanf("%d",&count);
```

```
 fibonacci(count);
}

int fibonacci(int num)
{
   if ( num == 0 )
      return 0;
   else if ( num == 1 )
      return 1;
   else
      return ( fibonacci(num-1) + fibonacci(num-2) );
}
```

In this example, the number of called functions in `fibonacci` is 1. The called function is `fibonacci` itself.

Metric Information

Group: Function
Acronym: `CALLS`

See Also

Number of Calling Functions

Number of distinct callers of a function

Description

This metric measures the number of distinct callers of a function.

Calls through a function pointer are not counted. Calls in unreachable code are counted. Even if a caller calls a function more than once, it is counted only once when this metric is calculated.

The recommended upper limit for this metric is 5. For more self-contained code, try to enforce an upper limit on this metric.

Examples

Same Function Calling a Function Multiple Times

```
#include <stdio.h>

int getVal() {
    int myVal;
    printf("Enter a value:");
    scanf("%d", &myVal);
    return myVal;
}

int func() {
    int val=getVal();
    if(val<0)
        return 0;
    else
        return val;
}

int func2() {
    int val=getVal();
```

```
    while(val<0)
        val=getVal();
    return val;
}
```

In this example, the number of calling functions for `getVal` is 2. The calling functions are `func` and `func2`.

Recursive Function

```
#include <stdio.h>

void main() {
 int count;
 printf("How many numbers ?");
 scanf("%d",&count);
 fibonacci(count);
}

int fibonacci(int num)
{
   if ( num == 0 )
      return 0;
   else if ( num == 1 )
      return 1;
   else
      return ( fibonacci(num-1) + fibonacci(num-2) );
}
```

In this example, the number of calling functions for `fibonacci` is 2. The calling functions are `main` and `fibonacci` itself.

Metric Information

Group: Function
Acronym: `CALLING`

See Also

Number of Direct Recursions

Number of instances of a function calling itself directly

Description

This metric specifies the number of direct recursions in your project.

A direct recursion is a recursion where a function calls itself in its own body. If indirect recursions do not occur, the number of direct recursions is equal to the number of recursive functions.

The recommended upper limit for this metric is 0. To avoid the possibility of exceeding available stack space, do not use recursions in your code. To detect use of recursions, check for violations of `MISRA C:2012 Rule 17.2`.

Examples

Direct Recursion

```
int getVal(void);

void main() {
    int count = getVal(), total;
    assert(count > 0 && count <100);
    total = sum(count);
}

int sum(int val) {
    if(val<0)
        return 0;
    else
        return (val + sum(val-1));
}
```

In this example, the number of direct recursions is 1.

Metric Information

Group: Project
Acronym: AP_CG_DIRECT_CYCLE

See Also

Number of Executable Lines

Number of executable lines in function body

Description

This metric measures the number of executable lines in a function body. When calculating the value of this metric, Polyspace excludes declarations without static initializers, comments, blank lines, braces or preprocessing directives.

If the function body contains a `#include` directive, the included file source code is also calculated as part of this metric.

This metric is not calculated for C++ templates.

Examples

Function with Declarations, Braces and Comments

```
void func(int);

int getSign(int arg) {
    int sign;
    if(arg<0) {
        sign=-1;
        func(-arg);
        /* func takes positive arguments */
    }
    else if(arg==0)
        sign=0;
    else {
        sign=1;
        func(arg);
    }
    return sign;
}
```

In this example, the number of executable lines of `getSign` is 9. The calculation excludes:

- The declaration `int sign;`.
- The comment `/* ... */`.
- The two lines with braces only.

Metric Information

Group: Function
Acronym: FXLN

See Also

Number of Files

Number of source files

Description

This metric calculates the number of source files in your project.

Metric Information

Group: Project
Acronym: FILES

See Also

Number of Function Parameters

Number of function arguments

Description

This metric measures the number of function arguments.

If ellipsis is used to denote variable number of arguments, when calculating this metric, the ellipsis is not counted.

The recommended upper limit for this metric is 5. For less dependency between functions and fewer side effects, try to enforce an upper limit on this metric.

Examples

Function with Fixed Arguments

```
int initializeArray(int* arr, int size) {
}
```

In this example, `initializeArray` has two parameters.

Function with Type Definition in Arguments

```
int getValueInLoc(struct {int* arr; int size;}myArray, int loc) {
}
```

In this example, `getValueInLoc` has two parameters.

Function with Variable Arguments

```
double average ( int num, ... )
{
    va_list arg;
    double sum = 0;
```

```
    va_start ( arg, num );

    for ( int x = 0; x < num; x++ )
    {
        sum += va_arg ( arg, double );
    }
    va_end ( arg);

    return sum / num;
}
```

In this example, `average` has one parameter. The ellipsis denoting variable number of arguments is not counted.

Metric Information

Group: Function
Acronym: PARAM

See Also

Number of Goto Statements

Number of `goto` statements

Description

This metric measures the number of `goto` statements in a function.

`break` and `continue` statements are not counted.

The recommended upper limit on this metric is 0. For better readability of your code, avoid `goto` statements in your code. To detect use of `goto` statements, check for violations of `MISRA C:2012 Rule 15.1`.

Examples

Function with `goto` Statements

```
#define SIZE 10
int initialize(int **arr, int loc);
void printString(char *);
void printErrorMessage(void);
void printExecutionMessage(void);

int main()
{
    int *arrayOfStrings[SIZE],len[SIZE],i;
    for ( i = 0; i < SIZE; i++ )
    {
        len[i] = initialize(arrayOfStrings,i);
    }

    for ( i = 0; i < SIZE; i++ )
    {
        if(len[i] == 0)
            goto emptyString;
        else
            goto nonEmptyString;
```

```
        loop: printExecutionMessage();
    }

emptyString:
    printErrorMessage();
    goto loop;
nonEmptyString:
    printString(arrayOfStrings[i]);
    goto loop;
}
```

In this example, the function `main` has 4 `goto` statements.

Metric Information

Group: Function
Acronym: `GOTO`

See Also

Number of Header Files

Number of included header files

Description

This metric measures the number of header files in the project. Both directly and indirectly included header files are counted.

The metric gives a slightly higher number than the actual number of header files that you use because Polyspace® internal header files and header files included by those files are also counted. For the same reason, the metric can vary slightly even if you do not explicitly include new header files or remove inclusion of header files from your code. For instance, the number of Polyspace® internal header files can vary if you change your analysis options.

Metric Information

Group: Project
Acronym: `INCLUDES`

See Also

Number of Instructions

Number of instructions per function

Description

This metric measures the number of instructions in a function body.

The recommended upper limit for this metric is 50. For more modular code, try to enforce an upper limit for this metric.

Computation Details

The metric is calculated using the following rules:

- A simple statement ending with a `;` is one instruction.

  If the statement is empty, it does not count as an instruction.
- A variable declaration counts as one instruction only if the variable is also initialized.
- Control flow statements such as `if`, `for`, `break`, `goto`, `return`, `switch`, `while`, `do-while` count as one instruction.
- The following do not count as instructions by themselves:
  - Beginning of a block of code

    For instance, the following counts as one instruction:

    ```
    {
        var = 1;
    }
    ```
  - Labels

    For instance, the following counts as two instructions. The `case` labels do not count as instructions.

    ```
    switch (1) {  // Instruction 1: switch
        case 0:
        case 1:
    ```

```
        case 2:
        default:
        break;    // Instruction 2: break
    }
```

Examples

Calculation of Number of Instructions

```
int func(int* arr, int size) {
    int i, countPos=0, countNeg=0, countZero = 0;
    for(i=0; i<size; i++) {
        if(arr[i] >0)
            countPos++;
        else if(arr[i] ==0)
            countZero++;
        else
            countNeg++;
    }
}
```

In this example, the number of instructions in `func` is 9. The instructions are:

1. `countPos=0`
2. `countNeg=0`
3. `countZero=0`
4. `for(i=0;i<size;i++) { ... }`
5. `if(arr[i] >=0)`
6. `countPos++`
7. `else if(arr[i]==0)`

   The ending `else` is counted as part of the `if-else` instruction.
8. `countZero++`
9. `countNeg++`

Note This metric is different from the number of executable lines. For instance:

- `for(i=0;i<size;i++)` has 1 instruction and 1 executable line.
- The following code has 1 instruction but 3 executable lines.

```
for(i=0;
    i<size;
    i++)
```

Metric Information

Group: Function
Acronym: STMT

See Also

Number of Lines

Total number of lines in a file

Description

This metric calculates the number of lines in a file. When calculating the value of this metric, Polyspace includes comments and blank lines.

This metric is calculated for source files and header files in the same folders as source files. If you want:

- The metric reported for other header files, change the default value of the option `Generate results for sources and (-generate-results-for)`.
- The metric not reported for header files at all, change the value of the option `Do not generate results for (-do-not-generate-results-for)` to `all-headers`.

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Metric Information

Group: File
Acronym: `TOTAL_LINES`

See Also

Number of Lines Within Body

Number of lines in function body

Description

This metric calculates the number of lines in function body. When calculating the value of this metric, Polyspace includes declarations, comments, blank lines, braces and preprocessing directives.

If the function body contains a `#include` directive, the included file source code is also calculated as part of this metric.

This metric is not calculated for C++ templates.

Examples

Function with Declarations, Braces and Comments

```
void func(int);

int getSign(int arg) {
    int sign;
    if(arg<0) {
        sign=-1;
        func(-arg);
        /* func takes positive arguments */
    }
    else if(arg==0)
        sign=0;
    else {
        sign=1;
        func(arg);
    }
    return sign;
}
```

In this example, the number of executable lines of `getSign` is 13. The calculation includes:

- The declaration `int sign;`.
- The comment `/* ... */`.
- The two lines with braces only.

Metric Information

Group: Function
Acronym: `FLIN`

See Also

Number of Lines Without Comment

Number of lines of code excluding comments

Description

This metric calculates the number of lines in a file. When calculating the value of this metric, Polyspace excludes comments and blank lines.

This metric is calculated for source files and header files in the same folders as source files. If you want:

- The metric reported for other header files, change the default value of the option `Generate results for sources and (-generate-results-for)`.
- The metric not reported for header files at all, change the value of the option `Do not generate results for (-do-not-generate-results-for)` to `all-headers`.

For more information on analysis options, see the documentation for Polyspace Bug Finder or Polyspace Bug Finder Server.

Metric Information

Group: File
Acronym: `LINES_WITHOUT_CMT`

See Also

Number of Local Non-Static Variables

Total number of local variables in function

Description

This metric provides the number of local variables in a function.

The metric excludes static variables. To find number of static variables, use the metric `Number of Local Static Variables`.

Examples

Non-Structured Variables

```
int flag();

int func(int param) {
  int var_1;
  int var_2;
  if (flag()) {
      int var_3;
      int var_4;
    } else {
      int var_5;
    }
}
```

In this example, the number of local non-static variables in `func` is 5. The number does not include the function arguments and return value.

Arrays and Structured Variables

```
typedef struct myStruct{
   char  arr1[50];
   char  arr2[50];
   int   val;
```

```
} myStruct;

void func(void) {
  myStruct var;
  char localArr[50];
}
```

In this example, the number of local non-static variables in `func` is 2: the structured variable `var` and the array `localArr`.

Variables in Class Methods

```
class Rectangle {
    int width, height;
  public:
    void set (int,int);
    int area (void);
} rect;

int Rectangle::area (void) {
    int temp;
    temp = width * height;
    return(temp);
}
```

In this example, the number of local non-static variables in `Rectangle::area` is 1: the variable `temp`.

Metric Information

Group: Function
Acronym: `LOCAL_VARS`

See Also

Introduced in R2017a

Number of Local Static Variables

Total number of local static variables in function

Description

This metric provides the number of local static variables in a function.

Examples

Number of Static Variables

```
void func(void) {
  static int var_1 = 0;
  int var_2;
}
```

In this example, the number of static variables in `func` is 1. For examples of different types of variables, see `Number of Local Non-Static Variables`.

Metric Information

Group: Function
Acronym: `LOCAL_STATIC_VARS`

See Also

Introduced in R2017a

Number of Paths

Estimated static path count

Description

This metric measures the number of paths in a function.

The recommended upper limit for this metric is 80. If the number of paths is high, the code is difficult to read and can cause more orange checks. Try to limit the value of this metric.

Computation Details

The number of paths is calculated according to these rules:

- If the statements in a function do not break the control flow, the number of paths is one.

  Even an empty statement such as `;` or empty block such as `{}` counts as one path.
- The number of paths for a control flow statement is calculated as follows:
  - `if-else if-else`: The number of paths is the sum of paths calculated in the `if` block, each `else if` block, and the concluding `else` block. When the concluding `else` block is omitted, the path count is increased by 1.

    For instance, the statement `if(..) {} else if(..) {} else {}` counts as three paths. The statement `if() {}` counts as two paths, one for the `if` block and one for the omitted `else` block.
  - `switch-case`: Every `case` with `break` statement adds one to the path count. The `default` statement counts as one path, even if it is omitted.

    For instance, the statement `switch (var) { case 1: .. break; case 2: .. break; default: .. }` counts as three paths.
  - `for`, `while`, and `do-while`: The number of paths is equal to the number of paths in the loop body + 1.

    For instance, the statement `while(0) {;}` counts as two paths.

  - Ternary operators: A statement with a ternary operator such as

    ```
    result = a > b ? a : b;
    ```

    is counted as one statement that does not break the control flow. The number of paths is considered as one.
- If more than one control flow statement are present in a sequence, the number of paths is the product of the path count for each control flow statement.

  For instance, if a function has three `for` loops and two `if-else` statements, the number of paths is $2 \times 2 \times 2 \times 2 \times 2 = 32$.

  If many control flow statements are present in a function, the number of paths can be large. Nested control flow statements reduce the number of paths at the cost of increasing the depth of nesting. For an example, see “Function with Nested Control Flow Statements” on page 9-69.
- The software displays specific values in cases where the metric is not calculated:
  - If `goto` statements are present in the body of the function, Polyspace cannot calculate the number of paths. The software displays a metric value of -1.
  - If the number of paths reaches an internal limit, the calculation stops. The software displays this limit as the metric value. The limit is 9223372036854775807 (indicating the hexadecimal number 0x7fffffffffffffff).

Examples

Function with One Path

```
void func(int ch) {
    switch (ch)
    {
    case 1:
    case 2:
    case 3:
    case 4:
    default:
    }
}
```

In this example, `func` has one path.

Function with Control Flow Statement Causing Multiple Paths

```
void func(int ch) {
    switch (ch)
    {
    case 1:
        break;
    case 2:
        break;
    case 3:
        break;
    case 4:
        break;
    default:
    }
}
```

In this example, `func` has five paths. Apart from the path that goes through the `case`s and `default`, each `break` causes the creation of a new path.

Function with Nested Control Flow Statements

```
void func()
{
    int i = 0, j = 0, k = 0;
    for (i=0; i<10; i++)
    {
        for (j=0; j<10; j++)
        {
            for (k=0; k<10; k++)
            {
                if (i < 2 )
                    ;
                else
                {
                    if (i > 5)
                        ;
                    else
                        ;
                }
            }
        }
    }
}
```

In this example, `func` has six paths. The number is calculated as follows:

- The innermost `if-else` block counts as two paths.
- The outer `if-else` block counts as three paths, one path for the `if` block and the previous two paths for the `else` block.
- The innermost `for` loop counts as four paths, one path for the loop and the previous three paths for the `if-else` blocks.
- The next two outer loops add one path each.

Therefore, the number of paths in `func` is six.

Metric Information

Group: Function
Acronym: PATH

See Also

Number of Potentially Unprotected Shared Variables

Number of unprotected shared variables

Description

This metric measures the number of variables with the following properties:

- The variable is used in more than one task.
- At least one operation on the variable is not protected from interruption by operations in other tasks.

Examples

Unprotected Shared Variables

```
#include <limits.h>
int shared_var;

void inc() {
    shared_var+=2;
}

void reset() {
    shared_var = 0;
}

void task() {
    volatile int randomValue = 0;
    while(randomValue) {
        reset();
        inc();
        inc();
    }
}
```

```
void interrupt() {
    shared_var = INT_MAX;
}

void interrupt_handler() {
    volatile int randomValue = 0;
    while(randomValue) {
        interrupt();
    }
}

void main() {
}
```

In this example, `shared_var` is an unprotected shared variable if you specify `task` and `interrupt_handler` as entry points and do not specify protection mechanisms.

The operation `shared_var = INT_MAX` can interrupt the other operations on `shared_var` and cause unpredictable behavior.

Metric Information

Group: Project
Acronym: UNPSHV

See Also

Introduced in R2018b

Number of Protected Shared Variables

Number of protected shared variables

Description

This metric measures the number of variables with the following properties:

- The variable is used in more than one task.
- All operations on the variable are protected from interruption through critical sections or temporal exclusions.

Examples

Shared Variables Protected Through Temporal Exclusion

```
#include <limits.h>
int shared_var;

void inc() {
    shared_var+=2;
}

void reset() {
    shared_var = 0;
}

void task() {
    volatile int randomValue = 0;
    while(randomValue) {
        reset();
        inc();
        inc();
    }
}

void interrupt() {
    shared_var = INT_MAX;
```

```
}

void interrupt_handler() {
    volatile int randomValue = 0;
    while(randomValue) {
        interrupt();
    }
}

void main() {
}
```

In this example, `shared_var` is a protected shared variable if you specify the following options:

Option	Value

Entry points	`task`
	
	`interrupt_handler`

Temporally exclusive tasks	`task interrupt_handler`

The variable is shared between `task` and `interrupt_handler`. However, because `task` and `interrupt_handler` are temporally exclusive, operations on the variable cannot interrupt each other.

Shared Variables Protected Through Critical Sections

```
#include <limits.h>
int shared_var;

void inc() {
    shared_var+=2;
}

void reset() {
    shared_var = 0;
}

void take_semaphore(void);
void give_semaphore(void);
```

```
void task() {
    volatile int randomValue = 0;
    while(randomValue) {
        take_semaphore();
        reset();
        inc();
        inc();
        give_semaphore();
    }
}

void interrupt() {
    shared_var = INT_MAX;
}

void interrupt_handler() {
    volatile int randomValue = 0;
    while(randomValue) {
        take_semaphore();
        interrupt();
        give_semaphore();
    }
}

void main() {
}
```

In this example, `shared_var` is a protected shared variable if you specify the following:

Option	**Value**	

Entry points	`task`
	
	`interrupt_handler`	

Critical section details	**Starting routine**	**Ending routine**
	`take_semaphore`	`give_semaphore`

The variable is shared between `task` and `interrupt_handler`. However, because operations on the variable are between calls to the starting and ending procedure of the same critical section, they cannot interrupt each other.

Metric Information

Group: Project
Acronym: PSHV

See Also

Introduced in R2018b

Number of Recursions

Number of call graph cycles over one or more functions

Description

The metric provides a quantitative estimate of the number of recursion cycles in your project. The metric is the sum of:

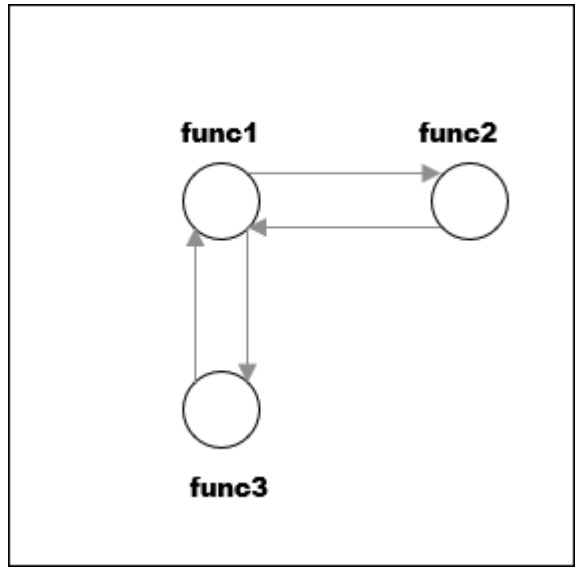
- Number of direct recursions (self recursive functions or functions calling themselves).
- Number of strongly connected components formed by the indirect recursion cycles in your project. If you consider the recursion cycles as a directed graph, the graph is strongly connected if there is a path between all pairs of vertices.

  To compute the number of strongly connected components:

  1 Draw the recursion cycles in your code.

  For instance, the recursion cycles in this example are shown below.

```
volatile int checkStatus;
void func1() {
   if(checkStatus) {
        func2();
   }
   else {
        func3();
   }
}

func2() {
   func1();
}

func3() {
   func1();
}
```



2 Identify the number of strongly connected components formed by the recursion cycles.

In the preceding example, there is one strongly connected component. You can move from any vertex to another vertex by following the paths in the graph.

The event list below the metric shows one of the recursion cycles in the strongly connected component.

Number of Recursions (Value: 1)
This metric shows the number of recursions, both direct and indirect.

	Event	File	Scope	Line
1	Recursion cycle: func1 => func3	file.c	file.c	2

Calls through a function pointer are not considered.

The recommended upper limit for this metric is 0. To avoid the possibility of exceeding available stack space, do not use recursions in your code. Recursions can tend to exhaust stack space easily. See examples of stack size growth with recursions described for this CERT-C rule that forbids recursions.

To detect use of recursions, check for violations of one of `MISRA C:2012 Rule 17.2`,MISRA C: 2004 Rule 16.2, `MISRA C++:2008 Rule 7-5-4` or JSF Rule 119. Note that these rule checkers consider explicit function calls only. For instance, in C++ code, the rule checkers ignore implicit calls to constructors during object creation. However, the metrics computation considers both implicit and explicit calls.

Examples

Direct Recursion

```
int getVal(void);

void main() {
    int count = getVal(), total;
    assert(count > 0 && count <100);
    total = sum(count);
}

int sum(int val) {
    if(val<0)
        return 0;
    else
        return (val + sum(val-1));
}
```

In this example, the number of recursions is 1.

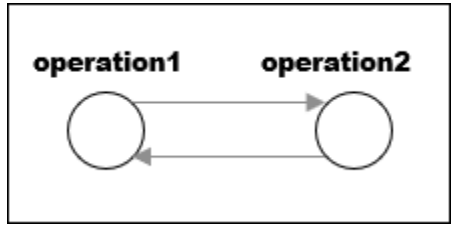
A direct recursion is a recursion where a function calls itself in its own body. For direct recursions, the number of recursions is equal to the number of recursive functions.

Indirect Recursion with One Call Graph Cycle

```
volatile int signal;

void operation1() {
```

```
    int stop = signal%2;
    if(!stop)
        operation2();
}

void operation2() {
    operation1();
}

void main() {
    operation1();
}
```

In this example, the number of recursions is one. The two functions `operation1` and `operation2` are involved in the call graph cycle `operation1` → `operation2` → `operation1`.



An indirect function is a recursion where a function calls itself through other functions. For indirect recursions, the number of recursions can be different from the number of recursive functions.

Multiple Call Graph Cycles Forming One Strongly Connected Component

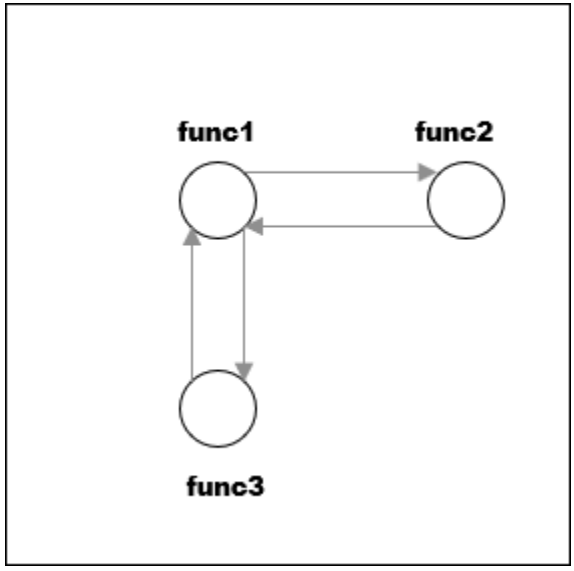
```
volatile int checkStatus;
void func1() {
   if(checkStatus) {
        func2();
   }
   else {
```

```
        func3();
   }
}

func2() {
   func1();
}

func3() {
   func1();
}
```

In this example, there are two call graph cycles:

- `func1` → `func2` → `func1`
- `func1` → `func3` → `func1`

However, the cycles form one strongly connected component. You can move from any vertex to another vertex by following the paths in the graph. Hence, the number of recursions is one.



Indirect Recursion with Two Call Graph Cycles

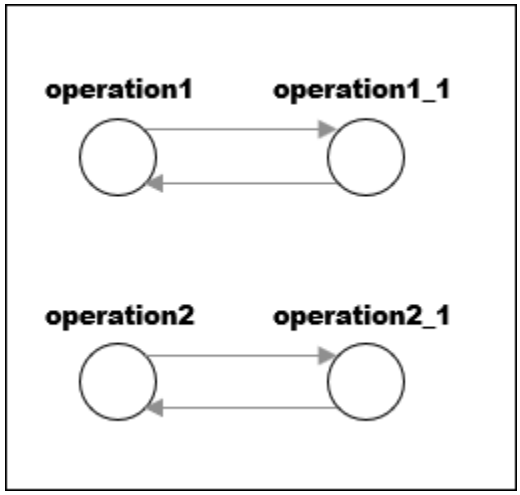
```
volatile int signal;

void operation1() {
    int stop = signal%2;
    if(!stop)
        operation1_1();
}


void operation1_1() {
    operation1();
}

void operation2() {
    int stop = signal%2;
    if(!stop)
        operation2_1();
}

void operation2_1() {
    operation1();
}

void main(){
    operation1();
    operation2();
}
```

In this example, the number of recursions is two.

There are two call graph cycles:

- `operation1` → `operation1_1` → `operation1`
- `operation2` → `operation2_1` → `operation2`

The call graph cycles form two strongly connected components.



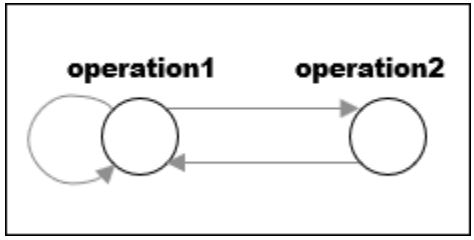
Same Function Called in Direct and Indirect Recursion

```
volatile int signal;

void operation1() {
    int stop = signal%3;
    if(stop==1)
        operation1();
    else if(stop==2)
        operation2();
}

void operation2() {
    operation1();
}

void main() {
    operation1();
}
```

In this example, the number of recursions is two:

- The strongly connected component formed by the cycle `operation1` → `operation2` → `operation1`.

- The self-recursive function `operation1`.



Metric Information

Group: Project
Acronym: `AP_CG_CYCLE`

See Also

Number of Return Statements

Number of `return` statements in a function

Description

This metric measures the number of `return` statements in a function.

The recommended upper limit for this metric is 1. If one return statement is present, when reading the code, you can easily identify what the function returns.

Examples

Function with Return Points

```
int getSign (int arg) {
    if(arg <0)
        return -1;
    else if(arg > 0)
        return 1;
    return 0;
}
```

In this example, `getSign` has 3 `return` statements.

Metric Information

Group: Function
Acronym: RETURN

See Also

Program Maximum Stack Usage

Maximum stack usage in the analyzed program

Description

This metric shows the maximum stack usage from your program.

The metric shows the maximum stack usage for the function with the highest stack usage. If you provide a complete application, the function with the highest stack usage is typically the `main` function because the `main` function is at the top of the call hierarchy. For a description of maximum stack usage for a function, see the metric .

Metric Information

Group: Project
Acronym: `PROG_MAX_STACK`

See Also

Introduced in R2017b

Program Minimum Stack Usage

Maximum stack usage in the analyzed program taking nested scopes into account

Description

This metric shows the maximum stack usage from your program, taking nested scopes into account.

The metric shows the minimum stack usage for the function with the highest stack usage. If you provide a complete application, the function with the highest stack usage is typically the `main` function because the `main` function is at the top of the call hierarchy. For a description of minimum stack usage for a function, see the metric .

Considering nested scopes is useful for compilers that reuse stack space for variables defined in nested scopes. For instance, in this code, the space for `var_1` is reused for `var_2`.

```
type func (type param_1, ...) {

  {
    /* Scope 1 */
    type var_1, ...;
  }
  {
    /* Scope 2 */
    type var_2, ...;
  }
}
```

Metric Information

Group: Project
Acronym: PROG_MIN_STACK

See Also

Introduced in R2017b

10

Polyspace Bug Finder Access Functions

cop-docker-agent

(DOS/UNIX) Launch cluster operator to manage Polyspace Access services

Syntax

```
cop-docker-agent [OPTIONS]
```

Description

`cop-docker-agent [OPTIONS]` launches the cluster operator (COP). If you do not specify additional `OPTIONS`, the cluster operator starts on port `8080` and uses the `HTTP` protocol.

Input Arguments

`OPTIONS` — Options to manage the COP or create a node

string

Options to specify and manage the connection settings of the cluster operator (COP) or to create a node.

General options

Option	Description
`--port` *`portNumber`*	Specify the server port number that you use to access the cluster operator web interface. The default port value is 8080 for HTTP protocol and 8443 for HTTPS.

Option	Description
`--data-dir` *`dirPath`*	Specify the full path to the folder of the `settings.json` file. If the file does not exist, the COP creates it in the specified folder. If the file already exists, the COP reuses its contents to configure the settings. The default folder is the current folder.
`--reset-password`	Reset the password that you use to log into the COP web interface.
`--help`	Display the help menu.

HTTPS configuration options

On Windows systems, all paths must point to local drives.

Option	Description
`--hostname` *`hostName`*	Specify the host name of the machine where you are running the COP. The host name you specify must match the `Common Name (CN)` you specify to obtain a signed certificate.
`--https-certificate-file` *`absolutePath`*	Specify the absolute path to the HTTPS certificate `PEM` file.
`--https-private-key-file` *`absolutePath`*	Specify the absolute path to the HTTPS private key `PEM` file that you used to generate the certificate.

Option	Description
`--https-trusted-certificates-file` *`absolutePath`*	Specify the full path to the certificate store where you store trusted certificate authorities. For instance, on a Linux Debian® distribution, `/etc/ssl/certs/ca-certificates.crt` . If you use self-signed certificates, use the same file that you specify for `--https-certificate-file`

New node configuration options

If you choose to install Polyspace Access on multiple machines, use these options to create nodes on the different machines. In the COP settings, for each service, you select the node of the machine on which you want to run the service.

Before you create a node, you must have an instance of the COP already running on at lease one machine. This other machine hosts the `master` node.

Option	Description
`--operator-host` *`hostName:port`*	Specify the host name and port number of the machine hosting the `master` node.
`--node-id` *`nodeName`*	Name of the node that you create. After you start the COP, you see this node listed in the COP web interface on the **Nodes** tab, and in the **Node:** drop-down lists in the **Settings** tab.

Examples

Configure HTTPS protocol with self-signed certificate

The cluster operator (COP) uses HTTP protocol by default. You can encrypt the data between the COP server and client machines by configuring the COP with HTTPS protocol.

Create a self-signed certificate and private key file by using the `openssl` toolkit.

```
openssl req -newkey rsa:2048 -new -nodes -x509 -days 365 \
-keyout private_key.pem -out certificate.pem
```

After you enter the command, follow the prompt on the screen. You can leave most fields blank, but you must provide a `Common Name`. The common name must match the host name of the machine running the COP. The command outputs a certificate file `certificate.pem` and a private key file `private_key.pem`.

Start an instance of the COP by using the certificate and private key files that you generated. In the command, specify the full path to the files.

```
./cop-docker-agent --hostname hostName\
--https-certificate-file fullPathTo/certificate.pem \
--https-private-key-file fullPathTo\private_key.pem \
--https-trusted-certificates-file fullPathTo/certificate.pem
```

You can now access the COP web interface from your browser by using `https://hostName:8443`, where *`hostName`* is the host name of the machine running the COP.

Create a node and run Polyspace Access on multiple machines

If you choose to install and run Polyspace Access on multiple machines, you must create nodes on each machine. You associate a Polyspace Access service with a node from the machine on which you run that service.

For instance, suppose you have two machines with host names `host1` and `host2`. You want to run the **Web Server** and **Database** services on `host2` and all the other services on `host1`.

From `host1`, start COP on port `8083`.

```
./cop-docker-agent --hostname host1 --port 8083
```

In the COP web interface at `http://host1:8083`, on the **Settings** tab, all the services have their **Node** parameter set to `master`.

Copy the COP binary and associated `TAR` files from `host1` to `host2`, for instance by using the `scp` command.

```
scp -r jdoe@host1:cop/install/dir ./
```

From host2, navigate to the folder that you copied from host1 and create a node new_node.

```
./cop-docker-agent --hostname host2 --operator-host host1:8083 --node-id new_node &
```

After you run the command, from the COP web interface at http://host1:8083, you see new_node listed in the **Nodes** tab. Click new_node to see a list of data volumes available for this node. If there are no volumes listed, create one.

Go to the **Settings** tab and set the **Node** attribute for the **Web sever** and **Database** to new_node, then set **Data volume** for the **Database** to one of the new_node volumes.

The **Upload directory** of the **ETL** and **Web server** are on different nodes. The path that you provide for each one must point to the same physical storage location.

Save the settings, go to the **Services** tab, click **PROVISION** and then **START ALL**. The **Database** and **Web sever** services are running on host2, while all the other services run on host1.

See Also

Topics

“Configure and Start the Cluster Operator”
“Configure Polyspace Access Services”

Introduced in R2018b