LabVIEW™

Code Interface Reference Manual

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About This Manual

The *LabVIEW Code Interface Reference Manual* describes Code Interface Nodes and external subroutines for users who need to use code written in conventional programming languages. The manual includes information about shared external subroutines, libraries of functions, memory and file manipulation routines, and diagnostic routines. Additional information not included in this manual is also available by selecting **Online Reference** from LabVIEW's **Help** menu.

Organization of This Manual

This manual is organized as follows:

- Chapter 1, *CIN Overview*, introduces the LabVIEW Code Interface Node (CIN), a node that links external code written in a conventional programming language to LabVIEW.
- Chapter 2, *CIN Parameter Passing*, describes the data structures that LabVIEW uses when passing data to a CIN.
- Chapter 3, *CIN Advanced Topics*, covers several topics that are needed only in advanced applications, including how to use the `CINInit`, `CINDispose`, `CINAbort`, `CINLoad`, `CINUnload`, `CINSave`, and `CINProperties` routines. The chapter also discusses how global data works within CIN source code, and how users of Windows 3.1, Windows 95, and Windows NT can call a DLL from a CIN.
- Chapter 4, *External Subroutines*, describes how to create and call shared external subroutines from other external code modules.
- Chapter 5, *Manager Overview*, gives an overview of the function libraries, called *managers*, which you can use in external code modules. These include the memory manager, the file manager, and the support manager. The chapter also introduces many of the basic constants, data types, and globals contained in the LabVIEW libraries.
- Appendix A, *CIN Common Questions*, answers some of the questions commonly asked by LabVIEW CIN users.
- Appendix B, *Customer Communication*, contains forms you can use to request help from National Instruments or to comment on our products and manuals.

- The *Glossary* contains an alphabetical list and description of terms used in this manual, including acronyms, abbreviations, metric prefixes, mnemonics, and symbols.

Conventions Used in This Manual

The following conventions are used in this manual:

bold	Bold text denotes the names of menus, menu items, parameters, dialog boxes, dialog box buttons or options, icons, windows, Windows 95 tabs, or LEDs.
italic	Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text from which you supply the appropriate word or value, as in Windows 3.*x*.
bold italic	Bold italic text denotes an activity objective, note, caution, or warning.
`monospace`	Text in this font denotes text or characters that you should literally enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames and extensions, and for statements and comments taken from programs.
`monospace italic`	Italic text in this font denotes that you must enter the appropriate words or values in the place of these items.
<>	Angle brackets enclose the name of a key on the keyboard—for example, <shift>. Angle brackets containing numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, DBIO<3..0>.
-	A hyphen between two or more key names enclosed in angle brackets denotes that you should simultaneously press the named keys—for example, <Control-Alt-Delete>.
paths	Paths in this manual are denoted using backslashes (\) to separate drive names, directories, folders, and files.
☞	This icon to the left of bold italicized text denotes a note, which alerts you to important information.

This icon to the left of bold italicized text denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.

Abbreviations, acronyms, metric prefixes, mnemonics, symbols, and terms are listed in the *Glossary*.

Related Documentation

The following documents contain information that you might find helpful as you read this manual:

- *G Programming Reference Manual*
- *LabVIEW User Manual*
- *LabVIEW Function and VI Reference Manual*
- LabVIEW *Online Reference*, available by selecting **Help»Online Reference**

Sun users might also find the following document useful:

- Sun Workshop CD-ROM, Sun Microsystems, Inc., U.S.A., 1997

Windows users might also find the following documents useful:

- Microsoft Windows documentation set, Microsoft Corporation, Redmond, WA, 1992-1995
- *Microsoft Windows Programmer's Reference*, Microsoft Corporation, Redmond, WA, 1992-1995
- *Win32 Programmer's Reference*, Microsoft Corporation, Redmond, WA, 1992-1995
- *Watcom C/C++ User's Guide* CD-ROM, Watcom Publications Limited, Waterloo, Ontario, Canada, 1995; Help file: "The Watcom C/C++ Compilers"
- Microsoft Visual C++ CD-ROM, Microsoft Corporation, Redmond, WA, 1997

Customer Communication

National Instruments wants to receive your comments on our products and manuals. We are interested in the applications you develop with our products, and we want to help if you have problems with them. To make it easy for you to contact us, this manual contains comment and configuration forms for you to complete. These forms are in Appendix B, *Customer Communication*, at the end of this manual.

1

CIN Overview

This chapter introduces the LabVIEW Code Interface Node (CIN), a node that links external code written in a conventional programming language to LabVIEW.

Introduction

A CIN is a block diagram node associated with a section of source code written in a conventional programming language. You compile the source code first and link it to form executable code. LabVIEW calls the executable code when the node executes, passing input data from the block diagram to the executable code, and returning data from the executable code to the block diagram.

The LabVIEW compiler can usually generate code fast enough for most of your programming tasks. However, you can use CINs for tasks a conventional language can accomplish more easily, such as tasks that are time-critical or require a great deal of data manipulation. CINs are also useful for tasks you cannot perform directly from the diagram, such as calling system routines for which no corresponding LabVIEW functions exist. CINs can also link existing code to LabVIEW, although you may need to modify the code so it uses the correct LabVIEW data types.

CINs execute synchronously, which means LabVIEW cannot use the execution thread used by the CIN for any other purpose. When a VI executes, LabVIEW monitors menus and the keyboard. When running multi-threaded, there is a separate thread for these tasks. When running single-threaded, the VI returns to LabVIEW to allow it time to scan menus and the keyboard, and run other VIs.

When CIN object code executes, it takes control of its execution thread. If LabVIEW has only a single thread of control, then all of LabVIEW is stopped until the CIN object code returns. On single-threaded operation systems such as Macintosh and Windows 3.1, CINs even prevent other applications from running. In multi-threaded operating systems such as Windows 95/NT, only the execution thread running the CIN is locked up. However, if there is only one execution thread, other VIs are prevented from running.

A VI executing a CIN can not be reset until the CIN completes—the executing CIN object code cannot be interrupted by LabVIEW. Although you can create VIs that use CINs and behave in a more asynchronous fashion, be aware of this potential problem if you intend to write a CIN that executes a long task and you need LabVIEW to multitask in the interim.

A CIN appears on the diagram as an icon with input and output terminals. You associate this node with a section of code you want LabVIEW to call. When it is time for the node to execute, LabVIEW calls the code associated with the CIN, passing it the specified data.

In some cases, you may want a CIN to perform additional actions at certain execution times. For example, you might want to initialize data structures at load time or free private data structures when the user closes the VI containing the CIN. For these situations, you can write routines LabVIEW calls at predefined times or when the node executes. Specifically, LabVIEW calls certain routines when the VI containing the CIN is loaded, saved, closed, aborted, or compiled. You generally use these routines in CINs that perform an on-going action, such as accumulating results from call to call, so you can allocate, initialize, and deallocate resources at the correct time. Most CINs perform a specific action at run time only.

After you have written your first CIN as described in this manual, writing new CINs is relatively easy. The work involved in writing new CINs is mostly in coding the algorithm, because the interface to LabVIEW remains the same, no matter what the development system.

Classes of External Code

LabVIEW supports code resources for CINs and external subroutines. An external subroutine is a section of code you can call from other external code. If you write multiple CINs that call the same subroutine, you may want to make the shared subroutine an external subroutine. The code for an external subroutine is a separate file; when LabVIEW loads a section of external code that references an external subroutine, it also loads the appropriate external subroutine into memory. Using an external subroutine makes each section of calling code smaller, because the external subroutine does not require embedded code. Further, you need to make changes only once if you want to modify the subroutine.

☞ **Note** ***LabVIEW does not support code resources for external subroutines on the Power Macintosh. If you are working with a Power Macintosh, you should use shared libraries instead of external subroutines. For information on building shared libraries, consult your development environment documentation.***

Although LabVIEW for Solaris 2.x, HP-UX, and Concurrent PowerMAX support external routines, it is recommended you use UNIX shared libraries instead, because they are a more standard library format.

Supported Languages

The interface for CINs and external subroutines supports a variety of compilers, although not all compilers can create code in the correct executable format.

External code must be compiled as a form of executable appropriate for a specific platform. The code must be relocatable, because LabVIEW loads external code into the same memory space as the main application.

Macintosh

LabVIEW for the Macintosh uses external code as a customized code resource (for 68K) or shared library (for Power Macintosh) that is prepared for LabVIEW using the separate utilities `lvsbutil.app` for THINK C and Metrowerks CodeWarrior, and `lvsbutil.tool` for the Macintosh Programmer's Workshop. These utilities are included with LabVIEW.

The LabVIEW utilities and object files are compatible with the three major C development environments for the Power Macintosh:

- THINK C, version 7 for Macintosh and Symantec C++ version 8 for Power Macintosh, from Symantec Corporation of Cupertino, CA
- Metrowerks CodeWarrior from Metrowerks Corporation of Austin, Texas
- Macintosh Programmer's Workshop (MPW) from Apple Computer, Inc. of Cupertino, CA

LabVIEW header files are compatible with these three environments. Header files may need modification for other environments.

CINs compiled for the 68K Macintosh will not be recognized by LabVIEW for the Power Macintosh, and vice versa.

LabVIEW does not currently work with fat binaries (a format including multiple executables in one file, in this case both 68K and Power Macintosh executables).

Microsoft Windows 3.1

LabVIEW for Windows supports external code compiled as a `.REX` file and prepared for LabVIEW using an application included with LabVIEW. This application requires `dos4gw.exe`, which comes with Watcom C. LabVIEW is a 32-bit, flat memory-model application, so you must compile external code for a 32-bit memory model when you install the Watcom C compiler.

Watcom C is the only LabVIEW-supported compiler that can create 32-bit code of the correct format.

Microsoft Windows 95 and Windows NT

You can use CINs in LabVIEW for Windows 95/NT created with any of the following compilers.

- The Microsoft Visual C++ compiler.
- Symantec C Compiler.

  See the *Microsoft Windows 95 and Windows NT* subsection of the *Compile the CIN Source Code* section of this chapter for information on how to create a CIN using these compilers.
- The Watcom C/386 compiler for Windows 3.1.

  In most cases, you can use CINs created using the Watcom C compiler for Windows 3.1 with LabVIEW for Windows 95/NT. See the *Microsoft Windows 3.x* subsection of the *Compile the CIN Source Code* section of this chapter for more information on using the Watcom C compiler for Windows 3.1.

☞ **Note** ***Under Windows 95 and Windows NT, do not call CINs created using the Watcom C compiler that call DLLs and system functions or that access hardware directly. The technique Watcom uses to call such code under Windows 3.1 does not work under Windows 95 or Windows NT.***

Solaris

LabVIEW for Sun supports external code compiled in `a.out` format under Solaris 1.*x* and a shared library format under Solaris 2.*x*. These formats are prepared for LabVIEW using a LabVIEW utility.

The unbundled Sun ANSI C compiler is the only compiler tested thoroughly with LabVIEW. The header files are compatible with the unbundled Sun ANSI C Compiler and may need modification for other compilers.

HP-UX and Concurrent

LabVIEW for HP-UX and Concurrent support external code compiled as a shared library. This library is prepared for LabVIEW using a LabVIEW utility.

The HP-UX C/ANSI C compiler and Concurrent C Compiler are the only compilers tested thoroughly with LabVIEW.

Steps for Creating a CIN

You create a CIN by first describing in LabVIEW the data you want to pass to the CIN. You then write the code for the CIN using one of the supported programming languages. After you compile the code, you run a utility that puts the compiled code into a format LabVIEW can use. You then instruct LabVIEW to load the CIN.

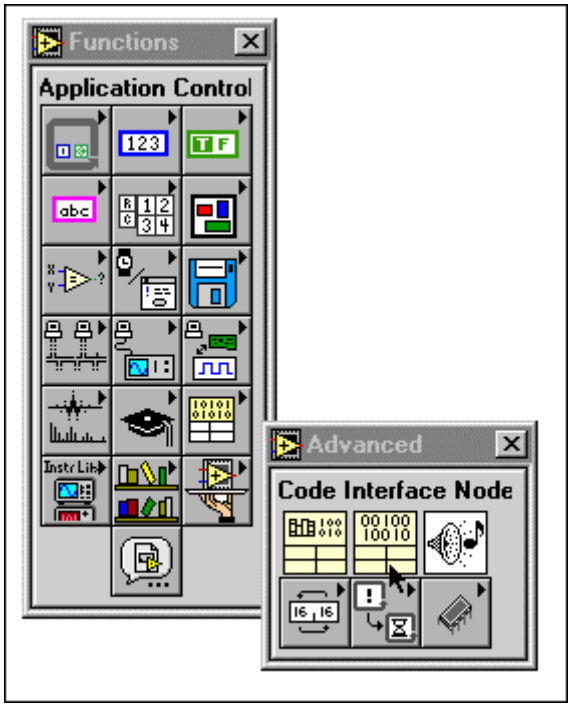
If you execute the VI at this point, and the block diagram needs to execute the CIN, LabVIEW calls the CIN object code and passes any data wired to the CIN. If you save the VI after loading the code, LabVIEW saves the CIN object code along with the VI so LabVIEW no longer needs the original code to execute the CIN. You can update your CIN object code with new versions at any time.

The `examples` directory contains a `cins` directory that includes all of the examples given in this manual. The names of the directories in the `cins` directory correspond to the CIN name given in the examples.

The following steps explain how to create a CIN.

Place the CIN on a Block Diagram

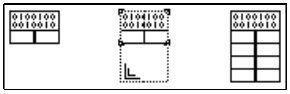
Select the Code Interface Node function from the **Advanced** palette of the **Functions** palette, as shown in the following illustration.



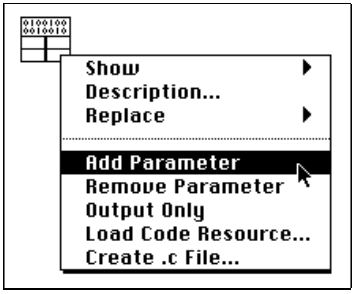
Add Input and Output Terminals to the CIN

A CIN has terminals with which you can indicate which data passes to and from a CIN. Initially, the CIN has one set of terminals, and you can pass a single value to and from the CIN. You add additional terminals by resizing the node or by selecting **Add Parameter** from the CIN terminal pop-up menu. Both methods are shown in the following illustration.

You can resize the node to add parameters,



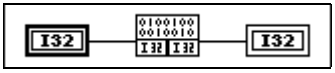
or use the pop-up menu to add a parameter.



Each pair of terminals corresponds to a parameter LabVIEW passes to the CIN. The two types of terminal pairs are input-output and output-only.

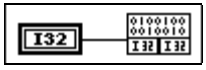
Input-Output Terminals

By default, a terminal pair is input-output; the left terminal is the input terminal, and the right terminal is the output terminal. As an example, consider a CIN that has a single terminal pair. Assume a 32-bit integer control is wired to the input terminal, and a 32-bit integer indicator is wired to the output terminal, as shown in the following illustration.



When the VI calls the CIN, the only argument LabVIEW passes to the CIN object code is a pointer to the value of the 32-bit integer input. When the CIN completes, LabVIEW then passes the value referenced by the pointer to the 32-bit integer indicator. When you wire controls and indicators to the input and the output terminals of a terminal pair, LabVIEW assumes the CIN can modify the data passed. If another node on the block diagram needs the input value, LabVIEW may have to copy the input data before passing it to the CIN.

Now consider the same CIN, but with no indicator wired to the output terminal, as shown in the following illustration.

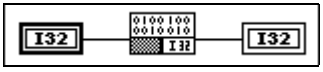


If you do not wire an indicator to the output terminal of a terminal pair, LabVIEW assumes the CIN will not modify the value you pass to it. If another node on the block diagram uses the input data, LabVIEW does

not copy the data. The source code should not modify the value passed into the input terminal of a terminal pair if you do not wire the output terminal. If the CIN does modify the input value, nodes connected to the input terminal wire may receive the modified data.

Output-Only Terminals

If you use a terminal pair only to return a value, make it an output-only terminal pair by selecting **Output Only** from the terminal pair pop-up menu. If a terminal pair is output-only, the input terminal is gray, as shown in the following illustration.



For output-only terminals, LabVIEW creates storage space for a return value and passes the value by reference to the CIN the same way it passes values for input-output terminal pairs. If you do not wire a control to the left terminal, LabVIEW determines the type of the output parameter by checking the type of the indicator wired to the output terminal. This can be ambiguous if you wire the output to two destinations that have different data types. You can remove this ambiguity by wiring a control to the left (input) terminal of the terminal pair as shown in the preceding figure. In this case, output terminal takes on the same data type as the input terminal. LabVIEW uses the input type only to determine the data type for the output terminal; the CIN does not use or affect the data of the input wire.

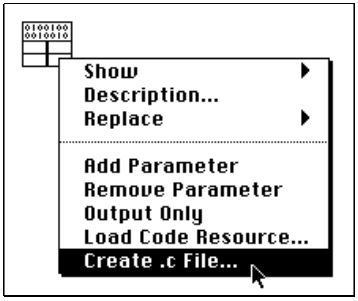
To remove a pair of terminals from a CIN, pop up on the terminal you want to remove and choose **Remove Terminal** from the menu. LabVIEW disconnects wires connected to the deleted terminal pair. Wires connected to terminal pairs below the deleted pair remain attached to those terminals and stretch to adjust to the terminals' new positions.

Wire the Inputs and Outputs to the CIN

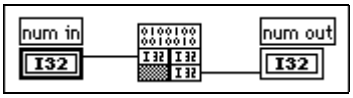
Connect wires to all the terminal pairs on the CIN to specify the data you want to pass to the CIN, and the data you want to receive from the CIN. The order of terminal pairs on the CIN corresponds to the order in which parameters are passed to the code. Notice you can use any LabVIEW data types as CIN parameters. Thus, you can pass arbitrarily complex hierarchical data structures, such as arrays containing clusters which may in turn contain other arrays or clusters to a CIN. See Chapter 2, *CIN Parameter Passing*, for a description of how LabVIEW passes parameters of specific data types to CINs.

Create .c File

If you select **Create .c File...** from the CIN pop-up menu, as shown in the following illustration, LabVIEW creates a `.c` file in the style of the C programming language. The `.c` file describes the routines you must write and the data types for parameters that pass to the CIN.



For example, consider the following call to a CIN, which takes a 32-bit integer as an input and returns a 32-bit integer as an output.



The following code excerpt is the initial `.c` file for this node. Eight routines may be written for the CIN. The `CINRun` routine is required—the others are optional. If an optional routine is not present, a default routine is supplied when the CIN is built.

These eight routines are discussed in detail in subsequent chapters. The `.c` file is presented here to give you an idea of what LabVIEW creates at this stage in building a CIN.

```
/*
 * CIN source file
 */

#include "extcode.h"

CIN MgErr CINRun(int32 *num_in, int32 *num_out);

CIN MgErr CINRun(int32 *num_in, int32 *num_out) {

    /* ENTER YOUR CODE HERE */
    return noErr;
    }
```

This .c file is a template in which you must write C code. Notice extcode.h is automatically included; it is a file that defines basic data types and a number of routines that can be used by CINs and external subroutines. extcode.h defines some constants and types whose definitions may conflict with the definitions of system header files. The LabVIEW cintools directory also contains a file, hosttype.h, that resolves these differences. This header file also includes many of the common header files for a given platform.

Always use #include "extcode.h" at the beginning of your source code. If your code needs to make system calls, also use #include "hosttype.h" immediately after #include "extcode.h", and then include your system header files. hosttype.h includes only a subset of the .h files for a given operating system. If the .h file you need is not included by hosttype.h, you can include it in the .c file for your CIN just after you include hosttype.h.

LabVIEW calls the CINRun routine when it is time for the node to execute. CINRun receives the input and output values as parameters. The other routines (CINLoad, CINSave, CINUnload, CINAbort, CINInit, CINDispose, and CINProperties) are housekeeping routines, called at specific times to give you the opportunity to take care of specialized tasks with your CIN. For instance, CINLoad is called when a VI is first loaded. If you need to accomplish some special task when your VI is first loaded, put the code for that task in the CINLoad routine. To do this, write your CINLoad routine as follows:

```
CIN MgErr CINLoad(RsrcFile reserved) {
       Unused (reserved);
       /* ENTER YOUR CODE HERE */
       return noErr;
       }
```

In general, you only need to write the CINRun routine. The other routines are supplied for instances when you have special initialization needs, such as when your CIN must maintain some information across calls, and you want to preallocate or initialize global state information. The following code shows how to fill out the CINRun routine from the previously shown LabVIEW-generated .c file to multiply a number by two. This code is included for illustrative purposes. Chapter 2, *CIN Parameter Passing*, discusses how LabVIEW passes data to a CIN, with several examples.

```
CIN MgErr CINRun(int32 *num_in, int32 *num_out) {
   *num_out = *num_in * 2;
   return noErr;
   }
```

Special Macintosh Considerations

If you compile your code for a 68K Macintosh, there are certain circumstances under which you must use the ENTERLVSB and LEAVELVSB macros at the entry and exit of some functions. These macros ensure the global context register (A5 for MPW builds, A4 for Symantec/THINK and Metrowerks builds) for your CIN is established during your function, and the caller's is saved and restored. This is necessary to enable you to reference global variables, call external subroutines, and call LabVIEW routines such as those described in subsequent chapters.

You need not use these macros in any of the eight predefined entry points (CINRun, CINLoad, CINUnload, CINSave, CINInit, CINDispose, CINAbort, and CINProperties), because the CIN libraries already establish and restore the global context before and after calling these routines. Using them here would be harmless, but unnecessary.

However, if you create any other entry points to your CIN, you should use these macros. You create another entry point to your CIN whenever you pass the address of one of your functions to some other piece of code that may call your function later. An example of this is the use of the QSort routine in the LabVIEW support manager (described in the *CIN Function Overview* section of the LabVIEW *Online Reference*). You must pass a comparison routine to QSort. This routine gets called directly by QSort, without going through the CIN library. Therefore it is your responsibility to set up your global context with ENTERLVSB and LEAVELVSB.

To use these macros properly, place the ENTERLVSB macro at the beginning of your function between your local variables and the first statement of the function. Place the LEAVELVSB macro at the end of your function just before returning, as in the following example.

```
CStr gNameTable[kNNames];

int32 MyComparisonProc(int32 *pa, int32 * pb)
    {
    int32 comparisonResult;

    ENTERLVSB

    comparisonResult = StrCmp(gNameTable[*pa],
    gNameTable[*pb]);

    LEAVELVSB
    return comparisonResult;
    }
```

The function MyComparisonProc is an example of a routine that might be passed to the QSort routine. Because it explicitly references a global variable (gNameTable), it must use the ENTERLVSB and LEAVELVSB macros. There are other things that can implicitly reference globals. Depending on the compiler and settings of various options, literal strings may also be referenced as globals.

It is best to always use the ENTERLVSB and LEAVELVSB macros whenever you create a new entry point to your CIN.

When you use these macros, be sure your function does not return before calling the LEAVELVSB macro. One technique is to use a goto endOfFunction statement (where endOfFunction is a label just before the LEAVELVSB macro at the end of your function) in place of any return statements you may place in your function.

Compile the CIN Source Code

You must compile the source code for the CIN in a format LabVIEW can use. There are two steps to this process. First you compile the code using a compiler LabVIEW supports. Then you use a LabVIEW utility to modify the object code, putting it into a format LabVIEW can use.

Because the compiling process is often complex, LabVIEW includes utilities that simplify the process. These utilities take a simple specification for a CIN and create object code you can load into LabVIEW. These tools vary depending on the platform and compiler you use. The following sections summarize the steps for each platform.

☞ **Note** ***Compiling the source code is different for each platform. Look under the heading for your platform and compiler in the following sections to find the instructions for your system.***

Every source code file for a CIN should list `#include "extcode.h"` ***before any other code. If your code needs to make system calls, you should also use*** `#include "hosttype.h"` ***immediately after*** `#include "extcode.h"`**.**

Macintosh

LabVIEW for the Macintosh uses external code as a customized code resource (on a 68K Macintosh) or as a shared library (on a Power Macintosh) prepared for LabVIEW using the separate utilities `lvsbutil.app` for THINK and Metrowerks or `lvsbutil.tool` for MPW. Both these utilities are included with LabVIEW.

You can create CINs on the Macintosh with compilers from any of the three major C compiler vendors: Symantec's THINK environment, Metrowerks' CodeWarrior environment, and Apple's Macintosh Programmer's Workshop (MPW) environment. Always use the latest Universal headers containing definitions for both 68K and Power Macintosh compilers.

The LabVIEW utilities for building Power Macintosh CINs are the same ones used for the 68K Macintosh and can be used to build both versions of a CIN. If you want to place both versions in the same folder, however, some development conflicts may arise. Because the naming conventions for object files and `.lsb` files are the same, make sure one version does not replace the other. These kinds of issues can be handled in different ways, depending on your development environment.

Some CIN code that compiles and works on the 68K Macintosh and calls Macintosh OS or Toolbox functions requires changes to the source code before it will work on the Power Macintosh. Any code that passes a function pointer to a Mac OS or Toolbox function must be modified to pass a Routine Descriptor (see Apple's *Inside Macintosh* chapter on the Mixed Mode Manager, available in the Macintosh on RISC SDK from APDA). Also, if you use any 68K assembly language in your CIN, it must be ported to either C or Power Macintosh assembly language.

THINK C for 68K (Version 7)

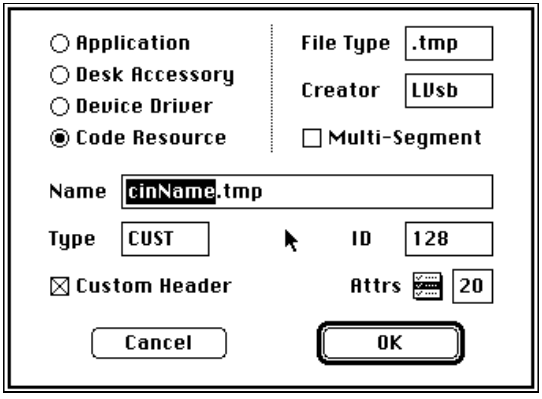
To create a THINK C CIN project, make a new folder for the project. Launch THINK C and create a new project in the new folder. The name of your THINK C project must match your CIN name exactly, and must not use any of the conventional project suffixes, such as `.π` or `.proj`. If you name your CIN `test`, your THINK C project must also be named `test`, so it produces a link map file named `test.map`. You should keep the new project and the CIN files associated with it within the same folder.

With THINK C 7, an easy way to set up your CIN project is to make use of the project stationery in the `cintools:Symantec-THINK Files: Project Stationery` folder. For THINK C 7 projects, the project stationery is a folder called `LabVIEW CIN TC7`. It provides a template

for new CINs with most of the settings you need. See the `Read Me` file in the `Project Stationery` folder for details.

When building a CIN using THINK C for 68K, many of the preferences can be set to whatever you wish. Others, however, must be set to specific values to correctly create a CIN. If for some reason you do not use the CIN project stationery, you will need to ensure the following settings in the THINK C Preferences dialog box are made:

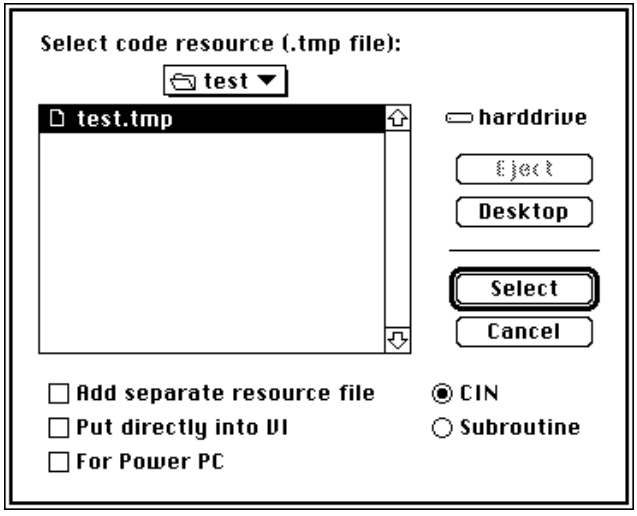
- Pull down the THINK C **Edit** menu and pop up on the **Options** item; select **THINK Project Manager...**. Under **Preferences**, check the **Generate link map** box, and then click on the **OK** button. Now go back to the **Options** item under the **Edit** menu and select **THINK C...**.
- To complete the project set-up process, select the **Require prototypes** button under **Language Settings** and then check the **Check Pointer Types** box. Under **Prefix**, delete the line `#include <MacHeaders>` if it is present. Finally, under **Compiler Settings**, check the **Generate 68881 instructions** box, the **Native floating-point format** box, and the **Generate 68020 instructions** box. You can use the **Copy** button at the top of the dialog box to make these settings the default settings for new projects, which will make the set-up process for subsequent CINs simpler.
- When you have finished selecting the options in the **Edit** menu, turn to the THINK C **Project** menu; select **Set Project Type...**. First, set the type to **Code Resource**. From the new options that appear, set the **File Type** to `.tmp`, the **Creator** to `LVsb`, the **Name** to the name of the CIN plus the extension `.tmp`, the **Type** to `CUST`, the **ID** to `128`, and check the **Custom Header** box. If you are creating a CIN called `test`, you must name the resource `test.tmp`, as shown in the following illustration.



After these parameters are set, add the libraries `CINLib.TC7` and `LabVIEWLib.TC7`, found in `cintools:Symantic-THINK Files: Think C 7 Libraries`, to the project. You must also add the default version of each standard CIN procedure not defined by your code. Each default procedure is in its own correspondingly named library, located in `cintools:Symantic-THINK Files:THINK C 7 Libraries`. These libraries are `CINLoad.TC7`, `CINUnload.TC7`, `CINInit.TC7`, `CINDispose.TC7`, `CINAbort.TC7`, `CINSave.TC7`, and `CINProperties.TC7`. Then add your `.c` files.

You are now ready to build the code resource. Go to the **Project** menu and select **Build Code Resource...**. A dialog box will appear, allowing you to save the code resource. The name of the code resource must be the same as the name of the CIN plus the extension `.tmp`.

After you build a code resource and give it a `.tmp` extension, you must run the application `lvsbutil.app`, also included with LabVIEW, to prepare external code for use as a CIN or external subroutine. This utility prompts you to select your `.tmp` file. The utility also uses the THINK C link map file, which carries a `.map` extension and must be in the folder with your `.tmp` file. The application `lvsbutil.app` uses the `.tmp` and the `.map` files to produce a `.lsb` file that can be loaded into a VI.



If you are making a CIN, select the **CIN** option in the dialog box, as shown in the above illustration. If you are making a CIN for the Power Macintosh, also check the **For Power PC** box. If you are making an external subroutine, select the **Subroutine** option.

Advanced programmers can check the **Add separate resource file** box to add additional resources to their CINs or the **Put directly into VI** box to put the `.lsb` code into a VI without opening it or launching LabVIEW. Remember the VI designated to receive the `.lsb` code must already contain `.lsb` code with the same name. Notice you cannot put the code directly into a library.

If your `.tmp` code resource file does not show up in the dialog box, check its file type. When building the `.tmp` file, specify the file type as `.tmp`, which is under the **Set Project Type...** menu item of the **Project** menu in THINK C. The `.lsb` file this application produces is what the LabVIEW CIN node should load.

☞ **Note** ***The THINK C compiler will only find*** `extcode.h` ***if the file*** `extcode.h` ***is located on the THINK C search path. You can place the*** `cintools` ***folder in the same folder as your THINK C application, or you can make sure the line*** `#include "extcode.h"` ***is a full pathname to*** `extcode.h` ***under THINK C. For example:***

```
#include "harddrive:cintools:extcode.h"
```

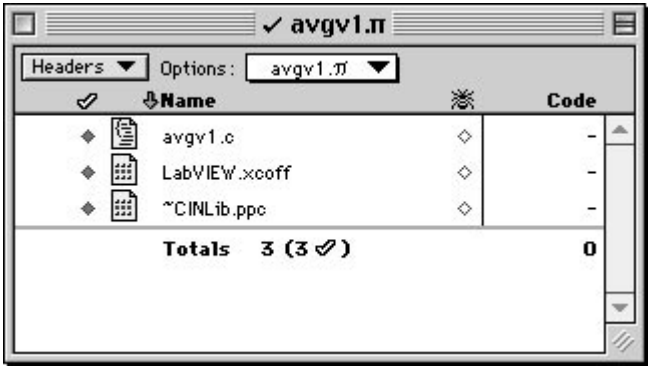
If you are using System 7.0 or later, you can extend the THINK C search path. To do so, first create a new folder in the same folder as your THINK C project and name it `Aliases`***. Then make an alias for the*** `cintools` ***folder, and drag this alias into your newly created*** `Aliases` ***folder. This technique enables the include line to read*** `#include "extcode.h"`***; therefore, it is not necessary to type the full pathname.***

Symantec C++ 8.0 for Power Macintosh

To create CINs using this environment, you will need to install the ToolServer application from the Symantec C++ 8.0 distribution disks. ToolServer is an Apple tool that performs the final linking steps in creating your CIN. It can be found in the `Apple Software:Tools` folder. Copy the `ToolServer 1.1.1` folder to your hard drive and place an alias to ToolServer in the `(Tools)` folder in your `Symantec C++ for PowerMac` folder.

You need the following files in your project to create a CIN for Power Macintosh.

- `~CINLib.ppc`. This file is shipped with LabVIEW and can be found in the `cintools:Symantic-THINK Files:Symantic C 8` folder.
- Your source files



You might also need the `LabVIEW.xcoff` file. This file is shipped with LabVIEW and can be found in the `cintools:PowerPC Libraries` folder. It is needed if you call any routines within LabVIEW, such as `DSSetHandleSize()` or `SetCINArraySize()`.

An easy way to set up your CIN project is to make use of the CIN project stationery in the `cintools:Symantec-THINK Files:Project Stationery` folder. For Symantec C version 8 projects the project stationery is a folder called `LabVIEW CIN SC8PPC`. The folder provides a template for new CINs containing almost all of the files and preference settings you need. See the `Read Me` file in the `Project Stationery` folder for details.

When building a CIN using Symantec C++ for PowerMac, you can set many of the preferences to whatever you wish. Others, however, must be set to specific values to correctly create a CIN. If you do not use the CIN project stationery, you need to make the following settings in the Symantec Project Manager **Options** dialog box (accessed from the **Project** menu):

- Project Type—Set the **Project Type** pop-up menu to **Shared Library**. Set the **File Type** text field to `.tmp`. Set the **Destination** text field to `cinName.tmp`, where `cinName` is the name of your CIN. Set the **Creator** to `LVsb`.
- Linker—Set the **Linker** pop-up menu to **PPCLink & MakePEF**. Set the **PPCLink settings** text field to `-export`

gLVExtCodeDispatchTable, LVSBhead. Set the **MakePEF settings** text field to have -librename LabVIEW.xcoff.o=LabVIEW in addition to the factory setting.

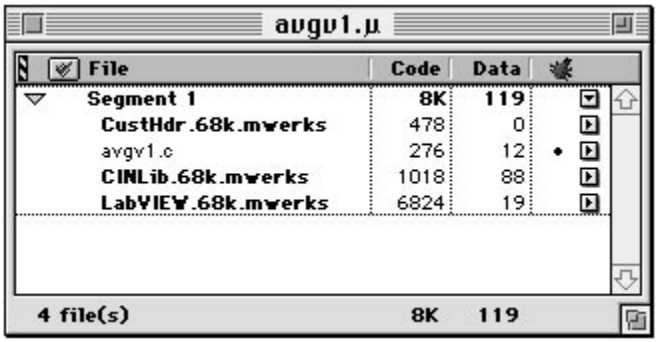
- Extensions—Set the **File Extension** text field to .ppc, the **Translator** pop-up menu to **XCOFF convertor**, and press the **Add** button.
- PowerPC C—In the **Compiler Settings** sub-page, select the **Align to 2 byte boundary** radio button. In the **Prefix** sub-page, remove the line that reads #include <PPCMacheaders>.

Build the CIN by selecting **Build Library** from the **Build** menu. Then convert the .tmp file with lvsbutil.app (with **For PowerPC** checked).

Metrowerks CodeWarrior for 68K

You need the following files in your project to be able to create a Metrowerks 68K CIN.

- CustHdr.68k.mwerks (This file *must* be the first file in the project.)
- CINLib.68k.mwerks
- LabVIEW.68k.mwerks
- Your source files



Note ***All of your files must be in a single segment. LabVIEW does not support multi-segment CINs.***

An easy way to set up your CIN project is to use the CIN project stationery in the cintools:Metrowerks Files:Project Stationery folder. For CodeWarrior 68K projects the project stationery is a file called LabVIEW CIN MW68K. The file provides a template for CINs containing almost all of the settings you need. See the Read Me file in the Project Stationery folder for details.

When building a CIN using CodeWarrior for 68K, you can set many of the preferences to whatever you wish. Others, however, must be set to specific values to correctly create a CIN. If you do not use the CIN project stationery, you need to make the following settings in the CodeWarrior Preferences dialog box:

- Language—Set the **Source Model** pop-up menu to **Apple C**. Empty the **Prefix File** text field.
- Processor—Check the **68881 Codegen** and **MPW C Calling Conventions** checkboxes. Leave the **4-Byte Ints** and **8-Byte Doubles** checkboxes unchecked.
- Linker—Check the **Generate Link Map** checkbox.
- Project—Set the **Project Type** pop-up menu to **Code Resource**. Set the **File Name** text field to *cinName*`.tmp`, where *cinName* is the name of your CIN. Set the **Resource Name** text field to the same text as in the **File Name** text field. Set the **Type** text field to `.tmp` and the **ResType** text field to `CUST`. Set the **ResID** text field to `128`. Set the **Header Type** pop-up menu to **Custom**. Set the **Creator** to `LVsb`.
- Access Paths—Add your `cintools` folder to the list of access paths.

Build the CIN by selecting **Make** from the CodeWarrior **Project** menu.

Caution ***This operation will destroy the contents of any other file named*** *cinName*`.tmp` ***in that folder. This could easily be the case if this is the same folder in which you build a Power Macintosh version of your CIN. If you are building for both platforms, you should keep separate directories for each. The convention used by the MPW CIN tools is to have two subdirectories named*** `PPCObj` ***and*** `M68Obj` ***where all platform-specific files reside.***

Note ***If you have both a ThinkC68K and a MetrowerksC68K map file,*** `lvbutil` ***cannot know in advance which compiler your*** `.tmp` ***file came from. It will first look for a ThinkC*** `.map` ***file, then for a Metrowerks*** `.map` ***file. To avoid any conflict, remove the unnecessary*** `.map` ***file before using*** `lvsbutil.app`**.**

When you have successfully built the *cinName*`.tmp` file, you must then use the `lvsbutil.app` application to create the *cinName*`.lsb` file.

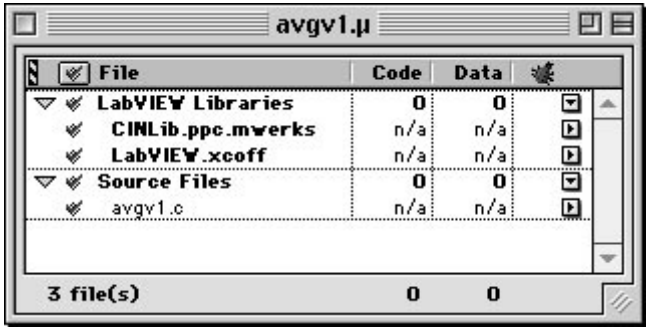
The `lvsbutil.app` application has a checkbox in the file selection dialog box labelled **For Power PC**. This checkbox *must not* be checked for 68K CINs. Select any other options you want for your CIN, and then select your *cinName*`.tmp` file. *cinName*`.lsb` will be created in the same folder as *cinName*`.tmp`.

Caution ***This operation will destroy the contents of any previous file named*** `cinName.lsb` ***in that folder. This could easily be the case if this is the same folder in which you build a 68K Macintosh version of your CIN.***

Metrowerks CodeWarrior for Power Macintosh

You need the following files in your CodeWarrior project to create a CIN for Power Macintosh.

- `CINLib.ppc.mwerks` is shipped with LabVIEW and is found in the `cintools:Metrowerks Files:PPC Libraries` folder.
- Your source files



You may also need the `LabVIEW.xcoff` file. This file is shipped with LabVIEW and is found in the `cintools:PowerPC Libraries` folder. It is needed if you call any routines within LabVIEW e.g., `DSSetHandleSize()`, or `SetCINArraySize()`.

Finally, if you call any routines from a system shared library, you must add the appropriate shared library interface file to your project's file list.

An easy way to set up your CIN project is to make use of the CIN project stationery in the `cintools:Metrowerks Files:Project Stationery` folder. For CodeWarrior PowerPC projects the project stationery is a file called `LabVIEW CIN MWPPC`. This file provides a template for CINs containing almost all of the settings you need. See the `Read Me` file in the `Project Stationery` folder for details.

When building a CIN using CodeWarrior for PPC, you can set many of the preferences to whatever you wish. Others, however, must be set to specific values to correctly create a CIN. If you do not use the CIN project stationery, you need to make the following settings in the CodeWarrior Preferences dialog box:

- Language—Set the **Source Model** pop-up menu to **Apple C**. Empty out the **Prefix File** text field (using **MacHeaders** will not work).
- Processor—Set the **Struct Alignment** pop-up menu to `68K`.
- Linker—Empty all of the **Entry Point** fields.
- PEF—Set the **Export Symbols** pop-up menu to **Use .exp file** and place a copy of the file `projectName.exp` (found in your `cintools:Metrowerks Files:PPC Libraries` folder) in the same folder as your CodeWarrior project. Rename this file to `projectName.exp`, where `projectName` is the name of the project file. CodeWarrior will look in this file to determine what symbols your CIN exports. LabVIEW needs these to link to your CIN.
- Project—Set the **Project Type** pop-up menu to **Shared Library**. Set the file name to be *`cinName`*`.tmp`, where *`cinName`* is the name of your CIN. Set the **Type** field to `.tmp`. Set the **Creator** to `LVsb`.
- Access Paths—Add your `cintools` folder to the list of access paths.

Build the CIN by selecting **Make** from the CodeWarrior **Project** menu.

Caution ***This operation will destroy the contents of any other file named*** *`cinName`*`.tmp` ***in that folder. This could easily be the case if this is the same folder in which you build a 68K Macintosh version of your CIN. If you are building for both platforms, you should keep separate folders for each. The convention used by the MPW CIN tools is to have two subdirectories named*** `PPCObj` ***and*** `M68Obj` ***where all platform-specific files reside.***

When you have successfully built the *`cinName`*`.tmp` file, you must then use the `lvsbutil.app` application to create the *`cinName`*`.lsb` file.

The `lvsbutil.app` application has a checkbox in the file selection dialog box labelled **For Power PC**. Check this box, along with any other options necessary for your CIN, and then select your *`cinName`*`.tmp` file. *`cinName`*`.lsb` will be created in the same folder as *`cinName`*`.tmp`.

Caution ***This operation will destroy the contents of any previous file named*** *`cinName`*`.lsb` ***in that folder. This could easily be the case if this is the same folder in which you build a 68K Macintosh version of your CIN.***

Macintosh Programmer's Workshop for 68K and Power Macintosh

You can use Macintosh Programmer's Workshop (MPW) to build CINs for either the Motorola 680*x*0 (68K) Macintosh or the Power Macintosh. Several scripts are available for the MPW environment to help you build CINs. To deal with the problem of building CINs for two different CPUs, these new scripts are designed to use two subdirectories in your CIN folder, `PPCObj` and `M68Obj`. The platform-specific object and CIN files are kept in these subdirectories. The scripts make use of the `MrC` compiler on PowerPC and the `SC` compiler on 68K Macintosh. Older compilers, `PPCC` and `C`, may also be used. The scripts are:

- `CINMake`—A script capable of building both Power Macintosh and 68K Macintosh CINs. It uses a simplified form of a makefile you provide. It can be run every time you need to rebuild your CIN.
- `LVMakeMake`—A script similar to the `lvmkmf` (LabVIEW Make Makefile) script available for building CINs under the Solaris operating system. It builds a skeletal but complete makefile you can then customize and use with the MPW `make` tool.

`CINMake` can be used for building both Power Macintosh and 68K Macintosh versions of your CINs. By default, the `CINMake` script builds 68K Macintosh CINs and puts the resulting *`cinName`*`.lsb` into the `M68Obj` folder.

You must have one makefile for each CIN. Name the makefile by appending `.lvm` to the CIN name. This indicates this is a LabVIEW makefile. The makefile should resemble the following pseudocode. Be sure each `Dir` command ends with the colon character (`:`).

`name =` *`name`*	Name for the code; indicates the base name for your CIN. The source code for your CIN should be in *`name`*`.c`. The code created by the makefile is placed in a new file, *`name`*`.lsb` (`.lsb` is a mnemonic for LabVIEW subroutine).
`type =` *`type`*	Type of external code you want to create. For CINs, you should use a type of `CIN`.
`codeDir =` *`codeDir:`*	Complete pathname to the folder containing the `.c` file used for the CIN.

`cinToolsDir = cinToolsDir:`
Complete pathname to the LabVIEW `cintools:MPW` folder, which is located in the LabVIEW folder.

`LVMVers = 2` Version of `CINMake` script reading this `.lvm` file.

`inclDir = -i inclDir:` (optional) Complete or partial pathname to a folder containing any additional `.h` files.

`otherM68ObjFiles = otherM68ObjFiles`
(optional) For 68K Macintosh only, list of additional object files (files with a `.o` extension) your code needs to compile. Separate the names of files with spaces.

`otherPPCObjFiles = otherPPCObjFiles`
(optional) For Power Macintosh only, list of additional object files (files with a `.o` extension) your code needs to compile. Separate the names of files with spaces.

`subrNames = subrNames` (optional) For 68K Macintosh only, list of external subroutines the CIN calls. You need `subrNames` only if the CIN calls external subroutines. Separate the names of subroutines with spaces.

`ShLibs = sharedLibraryNames`
(optional) For Power Macintosh only, a space-separated list of the link-time copies of import libraries with which the CIN must be linked. Each should be a complete path to the file.

`ShLibMaps = sharedLibMappings`

(optional) For Power Macintosh only, the command-line arguments to the `MakePEF` tool that indicate the mapping between the name of each link-time import library and the run-time name of that import library. These will usually look something like the following:

```
-librename libA.xcoff=libA
-librename libB.xcoff=libB
```

Notice only the file names are needed, not entire paths.

You must adjust the –`Dir` names to reflect your own file system hierarchy.

Modify your MPW command search path by appending the `cintools:MPW` folder to the default search path. This search path is defined by the MPW Shell variable `commands`.

`set commands "{commands}","<pathname to directory of cinToolsDir>"`

Go to the MPW Worksheet and enter the following commands. First, set your current folder to the CIN folder using the MPW `Directory` command:

`Directory <pathname to directory of your CIN>`

Next, run the LabVIEW `CINMake` script:

`CINMake <name of your CIN>`

If `CINMake` does not find a `.lvm` file in the current folder, it builds a file named *`cinName`*`.lvm`, and prompts you for necessary information. This file, *`cinName`*`.lvm`, is in a format compatible with building both Power Macintosh and 68K Macintosh CINs in the same folder. If `CINMake` finds a *`cinName`*`.lvm` but it does not have the line `LVMVers = 2`, saves the `.lvm` file in *`cinName`*`.lvm.old` and update the *`cinName`*`.lvm` file to be compatible with the new version of `CINMake`.

The format of the CINMake command follows, with the optional parameters listed in brackets.

```
CINMake [-MakeOpts “opts”] [-RShell] [-PPC/-MrC/-SC/-C]
[-dbg] [-noDelete] <name of your CIN>
```

-MakeOpts	opts specifies extra options to pass to make.
-Rshell	
-PPC/-MrC/-SC/-C	Use one of these options to specify the compiler to use.
-dbg	If this argument is specified, CINMake prints out statements describing what it is doing.
-noDelete	If this argument is specified, CINMake will not delete temporary files used when making the CIN.

You can use LVMakeMake to build an MPW makefile you can then customize for your own purposes. You should only have to run LVMakeMake once for a given CIN. You can modify the resulting makefile by adding the proper header file dependencies, or by adding other object files to be linked into your CIN. The format of a LVMakeMake command follows, with optional parameters listed in brackets.

```
LVMakeMake [-o makeFile] [-PPC] <name of your CIN>.make
```

-o	makeFile specifies the name of the output makefile. If this argument is not specified, LVMakeMake writes to standard output.
-PPC	If this argument is specified, a makefile suitable for building a Power Macintosh CIN is created. By default, a 68K Macintosh makefile is created.

For example, to build a Power Macintosh makefile for a CIN named myCIN, execute the following command:

```
LVMakeMake -PPC myCIN > myCIN.ppc.make
## creates the makefile
```

You can then use the MPW `make` tool to build your CIN, as shown in the following commands.

```
make -f myCIN.ppc.make> myCIN.makeout
## creates the build commands
myCIN.makeout
## executes the build commands
```

You should load the `.lsb` file this application produces into your LabVIEW CIN node.

Microsoft Windows 3.*x*

Microsoft Windows 3.*x* is a 16-bit operating system. A 16-bit application faces several obstacles when working with large amounts of information, such as manipulating arrays requiring more than 64 kilobytes of memory.

LabVIEW is a 32-bit application without most of the inherent limitations found in 16-bit applications. Because of the way CINs are linked to VIs, however, LabVIEW can use only code compiled for 32-bit applications. This is because CINs reside in the same memory space as VIs and work with LabVIEW data. To create CINs, a compiler must be able to create 32-bit relocatable object code.

The only compiler that currently supports the correct format of executables is Watcom C. The following section lists the steps for compiling a CIN with the Watcom compiler.

Watcom C Compiler

With the Watcom C compiler, you create a specification that includes the name of the file you want to create, relevant directories, and any external subroutines or object files the CIN needs. (External subroutines are described in Chapter 4, *External Subroutines*.) You then use the `wmake` utility included with Watcom to compile the CIN.

In addition to compiling the CIN, the makefile directs `wmake` to put the CIN in the appropriate form for LabVIEW.

The makefile should look like the following pseudocode. Append `.lvm` to the makefile name to indicate this is a LabVIEW makefile.

`name = name`	Name for the code; indicates the base name for your CIN. The source code for your CIN should be in `name.c`. The code created by the makefile is placed in a new file, `name.lsb` (`.lsb` is a mnemonic for LabVIEW subroutine).
`type = type`	Type of external code you want to create. For CINs, you should use a type of `CIN`.
`codeDir = codeDir`	Complete or partial pathname to the directory containing the `.c` file used for the CIN.
`wcDir = wcDir`	Complete or partial pathname to the overall Watcom directory
`cinToolsDir = cinToolsDir`	Complete or partial pathname to the LabVIEW `cintools` directory, which is located in the LabVIEW directory. This directory contains header files you can use for creating CINs, and tools the `wmake` utility uses to create the CIN.
`inclDir = inclDir`	(optional) Complete or partial pathname to a directory containing any additional `.h` files.
`objFiles = objFiles`	(optional) List of additional object files (files with an `.obj` extension) your code needs to compile. Separate the names of files with spaces.
`subrNames = subrNames`	(optional) List of external subroutines the CIN calls. You need `subrNames` only if the CIN calls external subroutines. Separate the names of subroutines with spaces.

```
!include $(CinToolsDir)\generic.mak
```

Execute the wmake command by entering the following in DOS.

```
wmake /f <name of your CIN>.lvm
```

Note ***The*** `wmake` ***utility sometimes erroneously stops a make with an incorrectly reported error when it is run in the DOS shell within Windows. If this happens, run it in normal DOS.***

The `wmake` utility scans the specified LabVIEW makefile and remembers the defined values. The last line of the makefile, `!include $(CinToolsDir)\generic.mak`, instructs `wmake` to compile the code resource based on instructions in the `generic.mak` file, which is stored in the `cintools` directory. The `wmake` utility compiles the code and then transforms it into a form LabVIEW can use. The resulting code is stored in a *`name`*`.lsb` file, where *`name`* is the CIN name given in the `name` line of the makefile.

Note ***You cannot link most of the Watcom C libraries to your CIN because precompiled libraries contain code that cannot be properly resolved by LabVIEW when it links a VI to a CIN. If you try to call those functions, your CIN may crash.***

LabVIEW provides functions that correspond to many of the functions in these libraries. These functions are described in subsequent chapters of this manual. If you need to call a function not supplied by LabVIEW, you can access the function from a dynamic link library (DLL). A CIN can call a DLL using the techniques described in the Watcom C manuals. A DLL can call any function from the C libraries. See Chapter 3, CIN Advanced Topics, for information on calling a DLL.

Microsoft Windows 95 and Windows NT

You can use the Microsoft Visual C++ compiler and Symantec C compiler to build CINs for LabVIEW for Windows 95/NT. With some restrictions, you can also use some CINs created using Watcom C for Windows 3.1.

Visual C++ Command Line

The method for building CINs using command line tools under Windows 95 and Windows NT is similar to the method for building CINs under Windows 3.1 using the Watcom C compiler.

1. Add a `CINTOOLSDIR` definition to your list of user environment variables.

   Under Windows NT, you can edit this list with the `System` control panel accessory. For example, if you installed LabVIEW for Windows 95/NT in `c:\lv50nt`, the CIN tools directory should be

`c:\lv50nt\cintools`. In this instance, you would add the following line to the user environment variables using the System control panel.

```
CINTOOLSDIR = c:\lv50nt\cintools
```

Under Windows 95, you must modify your `AUTOEXEC.BAT`, to set `CINTOOLSDIR` to the correct value.

2. Build a `.lvm` file (LabVIEW Makefile) for your CIN. LabVIEW for Windows 95/NT requires you to define fewer variables than LabVIEW for Windows 3.1. You must specify the following items:
   - name = name of CIN or external subroutine (`mult`, for example)
   - type = CIN or LVSB (depending on whether it is a CIN or an external subroutine)
   - `!include $(CINTOOLSDIR)\ntlvsb.mak`

   If your CIN uses extra object files or external subroutines, you can specify the `objFiles` and `subrNames` options. You do not need to specify the `codeDir` parameter, because the code for the CIN must be in the same directory as the makefile. You do not need to specify the `wcDir` parameter, because the CIN tools can determine the location of the compiler.

   You can compile the CIN code using the following command, where `mult` is the makefile name.

   ```
   nmake /f mult.lvm
   ```

   If you want to use standard C or Windows 95 or Windows NT libraries, define the symbol `cinLibraries`. For example, to use standard C functions in the preceding example, you could use the following `.lvm` file.

   ```
   name = mult
   type = CIN
   cinLibraries=libc.lib
   !include $(CINTOOLSDIR)\ntlvsb.mak
   ```

   To include multiple libraries, separate the list of library names using spaces.

Visual C++ IDE

To build CINs using the Visual C++ Integrated Development Environment, complete the following steps:

- Create a new DLL project. Select **File»New…** and select `Win32 Dynamic-Link Library` as the project type. You can name your project whatever you like.
- Add CIN objects and libraries to the project. Select **Project»Add To Project»Files…** and select `cin.obj`, `labview.lib`, `lvsb.lib`, and `lvsbmain.def` from the `Cintools\Win32` subdirectory. These files are needed to build a CIN.
- Add Cintools to the include path. Select **Project»Settings…** and change **Settings for:** to `All Configurations`. Select the **C/C++** tab and set the category to `Preprocessor`. Add the path to your cintools directory in the **Additional include directories:** field.
- Set alignment to `1 byte`. Select **Project»Settings…** and change **Settings For:** to `All Configurations`. Select the **C/C++** tab and set the category to `Code Generation`. Choose `1 Byte` from the **Struct member alignment:** tab.
- Choose run-time library. Select **Project»Settings…** and change **Settings for:** to `All Configurations`. Select the **C/C++** tab and set the category to `Code Generation`. Choose `Multithreaded DLL` from the **Use run-time library:** tab.
- Make a custom build command to run `lvsbutil`. Select **Project»Settings…** and change **Settings for:** to `All configurations`. Select the **Custom Build** tab and change the **Build commands** field to <*`your path to cintools`*>`\win32\lvsbutil $(TargetName) -d $(WkspDir)\$(OutDir)` and the Output file fields to `$(OutDir)$(TargetName).lsb`.

Symantec C

The process for creating CINs using Symantec C is similar to the process for Visual C++ Command Line. Use `smake` instead of `nmake` on your `.lvm` file.

☞ **Note** ***You cannot currently create external subroutines using Symantec C.***

Watcom C Compiler for Windows 3.1 under Windows 95 or Windows NT

CINs you have created using the Watcom C compiler for Windows 3.1 should work under Windows 95 or Windows NT. However, your CIN may not work without modification if it makes calls to communicate with hardware drivers, performs register or memory mapped I/O, or calls Windows 3.1 functions. Windows 3.1 drivers do not run under Windows 95 or Windows NT, so you must port any drivers you may have written for Windows 3.1 to Windows 95 or Windows NT. In addition, CINs cannot manipulate hardware directly. To perform register or memory-mapped I/O, you need to write a Windows 95 or Windows NT driver. If you call Windows 3.1 functions, you should check to make sure those functions are still valid under Windows 95 and Windows NT.

To create CINs using Watcom C for Windows 3.1, follow the Watcom C instructions given in the *Watcom C Compiler* subsection of the *Compile the CIN Source Code* section of this chapter. You must compile the source code for the CINs under Windows 3.1. Use the LabVIEW for Windows 3.1 CIN libraries to compile the CINs.

Solaris 1.*x*

LabVIEW for Sun can use external code compiled in `a.out` format and prepared for LabVIEW using a LabVIEW utility. The unbundled Sun C compiler is the only compiler tested thoroughly with LabVIEW. Other compilers that can generate code in `a.out` format might also work with LabVIEW, but this has not been verified. The C compiler that comes with the operating system does not use extended-precision floating-point numbers; code using this numeric type will not compile. However, the unbundled C compiler does use them.

Solaris 2.*x*

The preceding information for Solaris 1.*x* is true for Solaris 2.*x*, with one exception—LabVIEW 3.1 and higher for Solaris 2.*x* uses code compiled in a shared library format, rather than the `a.out` format previously specified.

Note ***LabVIEW 3.0 for Solaris 2.x supported external code compiled in `ELF` format.***

Existing Solaris 1.*x* and Solaris 2.*x* (for LabVIEW 3.0) CINs will not operate correctly if they reference functions not in the System V Interface Definition (SVID) for `libc`, `libsys`, and `libnsl`. Recompiling your existing CINs using the shared library format should ensure your CINs function as expected.

HP-UX and Concurrent PowerMAX

As previously stated, the HP-UX C/ANSI C compiler and Concurrent C Compiler are the only compilers tested with LabVIEW.

Unbundled Sun ANSI C Compiler, HP-UX C/ANSI C Compiler, and Concurrent C Compiler

With these compilers, you create a makefile using the shell script `lvmkmf` (LabVIEW Make Makefile), which creates a makefile for a given CIN. You then use the standard `make` command to make the CIN code. In addition to compiling the CIN, the makefile puts the code in a form LabVIEW can use.

The format for the `lvmkmf` command follows, with optional parameters listed in brackets.

```
lvmkmf [-o Makefile] [-t CIN] [-ext Gluefile] LVSBName
```

`LVSBName`, the name of the CIN or external subroutine you want to build, is required. If `LVSBName` is `foo`, the compiler assumes the source is `foo.c`, and the compiler names the output file `foo.lsb`.

`-o` is optional and supplies the name of the makefile `lvmkmf` creates. If you do not use this option, the makefile name defaults to `Makefile`.

`-t` is optional and indicates the type of external code you want to create. For CINs, you should use `CIN`, which is the default.

`-ext` is needed only if this external code calls external subroutines. The argument to this directive is the name of a file containing the names of all subroutines this code calls, with one name per line. The file is not necessary to run the `lvmkmf` script, but it must be present before you can successfully make the CIN. If you do not specify a `-ext` option, `lvmkmf` assumes the CIN does not reference any external subroutines.

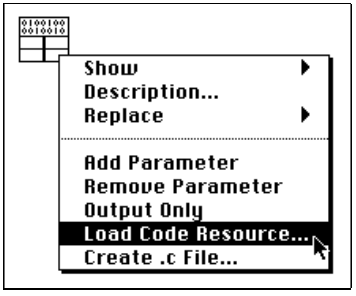
The makefile produced assumes the `cin.o`, `libcin.a`, `makeglue`*`XXX`*`.awk`, and `lvsbutil` files are in certain locations, where *`XXX`* is `BSD` on Solaris 1.x, `SVR4` or Solaris 2.x, `HP` on HP-UX, and `Concurrent` on Concurrent PowerMAX. If these assumptions are incorrect, you can edit the makefile to correct the pathnames.

If you specify the `-ext` argument to the `lvmkmf` script, the makefile creates temporary files. For example, if the gluefile name is `bar`, the makefile creates files `bar.s` and `bar.o`. Neither the CIN nor the makefile needs these files after the CIN has been created.

If you make external subroutines, you need to create a separate makefile for them. The `lvmkmf` script creates a file called `Makefile` unless you use the `-o` option. For this reason, you may want to place the code for each subroutine in separate directories to avoid writing over one `Makefile` with the other. If you want to place the code in the same directory, you need either to combine the two makefiles manually, or to create two separate makefiles (using the `-o` option to the `lvmkmf` script) and use `make -f <makefile>` to create the CIN or external subroutine.

Load the CIN Object Code

Load the code resource by choosing **Load Code Resource** from the CIN pop-up menu. Select the `.lsb` file you created in *Compile the CIN Source Code*.



This command loads your object code into memory and links the code to the current front panel/block diagram. After you save the VI, the file containing the object code does not need to be resident on the computer running LabVIEW for the VI to execute.

If you make modifications to the source code, you can load the new version of the object code using the **Load Code Resource** option. The file containing the object code for the CIN must have an extension of `.lsb`.

There is no limit to the number of CINs per block diagram.

LabVIEW Manager Routines

LabVIEW has a suite of routines that can be called from CINs and external subroutines. This suite of routines performs user-specified routines using the appropriate instructions for a given platform. These routines, which manage the functions of a specific operating system, are grouped into three categories: memory manager, file manager, and support manager.

External code written using the managers is portable—you can compile it without modification on any platform that supports LabVIEW. This portability has two advantages. First, the LabVIEW application is built on top of the managers—except for the managers, the LabVIEW source code is identical across platforms. Second, the analysis VIs are built mainly from CINs; the source code for these CINs is the same for all platforms.

For general information about the memory manager, the file manager, and the support manager, see Chapter 5, *Manager Overview*.

Online Reference

For descriptions of functions or file manager data structures, refer to the *CIN Function Overview* section of the LabVIEW *Online Reference*, available by selecting **Help»Online Reference**.

Pointers as Parameters

Some manager functions have a parameter that is a *pointer*. These parameter type descriptions are identified by a trailing asterisk (such as the **hp** parameter of the `AZHandToHand` memory manager function documented in the *CIN Function Overview* section of the LabVIEW *Online Reference*) or are type defined as such (such as the **name** parameter of the `FNamePtr` function documented in the *CIN Function Overview* section of the LabVIEW *Online Reference*). In most cases, this means the manager function will write a value to pre-allocated memory. In some cases, such as `FStrFitsPath` or `GetALong`, the function reads a value from the memory location, so you don't have to pre-allocate memory for a return value.

Table 1-1 lists the functions with parameters that return a value for which you must pre-allocate memory.

Table 1-1. Functions with Parameters Needing Pre-allocated Memory

AZHandToHand	FGetInfo	FPathToDString
AZMemStats	FGetPathType	FPathToPath
AZPtrToHand	FGetVolInfo	FRefNumToFD
DateToSecs	FMOpen	FStringToPath
DSHandToHand	FMRead	FTextToPath
DSMemStats	FMTell	FUnflattenPath
DSPtrToHand	FMWrite	GetAlong
FCreate	FNamePtr	NumericArrayResize
FCreateAlways	FNewRefNum	RandomGen
FFlattenPath	FPathToArr	SecsToDate
FGetAccessRights	FPathToAZString	SetALong
FGetEOF		

It is important to allocate space for this return value. The following examples illustrate correct and incorrect ways to call one of these functions from within a generic function `foo`:

Correct example:

```
foo(Path path) {
    Str255 buf; /* allocated buffer of 256 chars */
    File fd;
    MgErr err;

    err = FNamePtr(path, buf);
    err = FMOpen(&fd, path, openReadOnly,
    denyWriteOnly);
    }
```

Incorrect example:

```
foo(Path path) {
    PStr p;    /* an uninitialized pointer */
    File *fd;  /* an uninitialized pointer */
    MgErr err;

    err = FNamePtr(path, p);
    err = FMOpen(fd, path, openReadOnly
    denyWriteOnly);
    }
```

In the correct example, `buf` contains space for the maximum-sized Pascal string (whose address is passed to `FNamePtr`), and `fd` is a local variable (allocated space) for a file descriptor.

In the incorrect example, `p` is a pointer to a Pascal string, but the pointer is not initialized to point to any allocated buffer. `FNamePtr` expects its caller to pass a pointer to an allocated space, and writes the name of the file referred to by `path` into that space. Even if the pointer does not point to a valid place, `FNamePtr` will write its results there, with unpredictable consequences. Similarly, `FMOpen` will write its results to the space to which `fd` points, which is not a valid place because `fd` is uninitialized.

Debugging External Code

LabVIEW has a debugging window you can use with external code to display information at execution time. You can open the window, display arbitrary print statements, and close the window from any CIN or external subroutine.

Use the `DbgPrintf` function to create this debugging window. The format for `DbgPrintf` is similar to the format of the `SPrintf` function, which is described in the *CIN Function Overview* section of the LabVIEW *Online Reference*. `DbgPrintf` takes a variable number of arguments, where the first argument is a C format string.

DbgPrintf

syntax `int32 DbgPrintf(CStr cfmt, ..);`

The first time you call `DbgPrintf`, LabVIEW opens a window to display the text you pass to the function. Subsequent calls to `DbgPrintf` append new data as new lines in the window (you do not need to pass in the new line character to the function). If you call `DbgPrintf` with `NULL` instead of a format string, LabVIEW closes the debugging window. You cannot position or change the size of the window.

The following examples show how to use `DbgPrintf`.

```
DbgPrintf("");              /* print an empty line, opening
                            the window if necessary */

DbgPrintf("%H", var1);      /* print the contents of an
                            LStrHandle (LabVIEW string),
                            opening the window if necessary
                            */

DbgPrintf(NULL);            /* close the debugging window
                            */
```

Debugging CINs Under Windows 95/NT

Windows 95 and Windows NT support source level debugging of CINs using Microsoft's Visual C environment. To debug CINs under Windows 95/NT, complete the following steps.

1. Modify your CIN to set a debugger trap. You must do this to force Visual C to load your debugging symbols. The trap call must be done after the CIN is in memory. The easiest way to do this is to place it in the CINLoad procedure. Once the debugging symbols are loaded, you can set normal debug points inside Visual C. Windows 95 has a single method of setting a debugger trap, Windows NT can use the Windows 95 method or another.

The method common to Windows 95 and Windows NT is to insert a debugger break using an in-line assembly command:

```
_asm int 3;
```

Adding this to CINLoad gives you the following:

```
CIN MgErr CINLoad(RsrcFile reserved)
{
    Unused(reserved);
    _asm int 3;
    return noErr;
}
```

When the debugger trap is hit, Visual C pops up a debug window highlighting that line.

Under Windows NT, you may use the `DebugBreak` function. This function exists under Windows 95, but does not produce suitable results for debugging CINs. To use `DebugBreak`, include `<windows.h>` at the top of your file and place the call where you want to break:

```
#include <windows.h>
CIN MgErr CINLoad(RsrcFile reserved)
{
    Unused(reserved);
    DebugBreak();
    return noErr;
}
```

When that line executes, you will be in assembly. Step out of that function to get to the point of the `DebugBreak` call.

2. Rebuild your CIN with debugging symbols.

   If you built your CIN from the command line, add the following lines to the `.lvm` file of your CIN to add debug information to the CIN:

   ```
   DEGUG = 1
   cinLibraries = Kernel32.lib
   ```

   If you built your CIN using the IDE, build a debug version of the DLL. In **Projects»Settings…**, go to the **Debug** tab and select the **General** category. Enter your LabVIEW executable in the **Executable for debug session** box.

3. Run LabVIEW.

   If you built your CIN from the command line, start LabVIEW normally. When the debugger trap is run, a dialog box appears:

   A Breakpoint has been reached. Click OK to terminate application. Click CANCEL to debug the application.

   Click **CANCEL**. This launches the debugger, which attaches to LabVIEW, searches for the DLLs, then asks for the source file of your CIN. Point it to your source file, and the debugger loads the CIN source code. You can then debug your code.

   If you built your CIN using the IDE, open your CIN project and click the **GO** button. LabVIEW will be launched by Visual C.

Debugging CINs Under Sun or Solaris

It is not currently possible to use Sun's debugger, `dbx`, to debug CINs. The best you can do is use standard C `printf` calls or the `DbgPrintf` function mentioned earlier.

Debugging CINs Under HP-UX

You can debug CINs built on the HP-UX platform using `xdb`, the HP source level debugger. To do so, compile the CIN with debugging turned on. You must also enable shared library debugging with the `-s` flag and direct `xdb` to the source files for your CIN. For example, if your CIN source code is in the `tests/first` directory, you could invoke `xdb` with the following command:

```
xdb -s -d tests/first labview
```

See the `xdb` manual for more information. Once the CIN is loaded, break into the debugger and set your breakpoints. You may need to qualify function names with the name of the shared library. Qualified names are in the form `function_name@library_name`. The name of the shared library will not be what it was when compiled. Instead, it will be a unique name generated by the C library function `tmpnam`. The name will always begin with the string `LV`. Use the debugger command `mm` to display the memory map of all currently loaded shared libraries. CIN shared libraries are ordered by load time on the name space, so CINs loaded later appear in the memory map before CINs loaded earlier. As an example, to break at `CINRun` for the library `/usr/tmp/LVAAAa17732`, set the breakpoint as follows:

```
>b CINRun@LVAAAa17732
```

If you reload a CIN that is already loaded, the debugger will not function properly. If you change a CIN, you must quit and restart the debugger to enable it to work as desired.

2

CIN Parameter Passing

This chapter describes the data structures LabVIEW uses when passing data to a CIN.

Introduction

LabVIEW passes parameters to the `CINRun` routine. These parameters correspond to each of the wires connected to the CIN. You can pass any data type to a CIN you can construct in LabVIEW; there is no limit to the number of parameters you can pass to and from the CIN.

CIN .c File

When you select the **Create .c File...** option, LabVIEW creates a `.c` file in which you can enter your CIN code. The `CINRun` function and its prototype are given, and its parameters are typed to correspond to the data types being passed to the CIN in the block diagram. If you want to refer to any of the other CIN routines (`CINInit`, `CINLoad`, and so on), see their descriptions in Chapter 1, *CIN Overview*.

The `.c` file created is a standard C file, except LabVIEW gives the data types unambiguous names. C does not define the size of low-level data types—the `int` data type might correspond to a 16-bit integer for one compiler and a 32-bit integer for another compiler. The `.c` file uses names explicit about data type size, such as `int16`, `int32`, `float32`, and so on. LabVIEW comes with a header file, `extcode.h`, that contains typedefs associating these LabVIEW data types with the corresponding data type for the supported compilers of each platform.

`extcode.h` defines some constants and types whose definitions may conflict with the definitions of system header files. The LabVIEW `cintools` directory also contains a file, `hosttype.h`, that resolves these differences. This header file also includes many of the common header files for a given platform.

Note ***You should always use*** `#include "extcode.h"` ***at the beginning of your source code. If your code needs to include system header files, you should include*** `"extcode.h"`, `"hosttype.h"`, ***and then any system header files, in that order.***

If you write a CIN that accepts a single 32-bit signed integer, the `.c` file indicates the `CINRun` routine is passed an `int32` by reference. `extcode.h` typedefs an `int32` to the appropriate data type for the compiler you use (if it is a supported compiler); therefore, you can use the `int32` data type in external code you write.

How LabVIEW Passes Fixed Sized Data to CINs

As described in the *Steps for Creating a CIN* section of Chapter 1, *CIN Overview*, you can designate terminals on the CIN as either input-output or output-only. Regardless of the designation, LabVIEW passes data by reference to the CIN. When modifying a parameter value, be careful to follow the rules described for each kind of terminal in the *Steps for Creating a CIN* section of Chapter 1, *CIN Overview*. LabVIEW passes parameters to the `CINRun` routines in the same order as you wire data to the CIN—the first terminal pair corresponds to the first parameter, and the last terminal pair corresponds to the last parameter.

The following section describes how LabVIEW passes fixed sized parameters to CINs. See the *How LabVIEW Passes Variably Sized Data to CINs* section of this chapter for information on manipulating variably sized data such as arrays and strings.

Scalar Numerics

LabVIEW passes numeric data types to CINs by passing a pointer to the data as an argument. In C, this means LabVIEW passes a pointer to the numeric data as an argument to the CIN. Arrays of numerics are described in the subsequent *Arrays and Strings* section of this chapter.

Scalar Booleans

LabVIEW stores Booleans in memory as 8-bit integers. If any bit of the integer is 1, the Boolean is TRUE; otherwise the Boolean is FALSE. LabVIEW passes Booleans to CINs with the same conventions as for numerics.

Note ***In LabVIEW 4.x and earlier, Booleans were stored as 16-bit integers. If the high bit of the integer was 1, the Boolean was TRUE; otherwise the Boolean was FALSE.***

Refnums

LabVIEW treats a refnum the same way as it treats a scalar number and passes refnums with the same conventions it uses for numbers.

Clusters of Scalars

For a cluster, LabVIEW passes a pointer to a structure containing the elements of the cluster. LabVIEW stores fixed-size values directly as components inside of the structure. If a component is another cluster, LabVIEW stores this cluster value as a component of the main cluster.

Return Value for CIN Routines

The names of the CIN routines are prefaced in the header file with the words `CIN MgErr`, as shown in the following example.

```
CIN MgErr CINRun(...);
```

The LabVIEW header file `extcode.h`, defines the word CIN to be either Pascal or nothing, depending on the platform. Prefacing a function with the word `Pascal` causes some C compilers to use Pascal calling conventions instead of C calling conventions to generate the code for the routine. LabVIEW uses Pascal calling conventions on the Macintosh when calling CIN routines, so the header file declares the word CIN to be equivalent to Pascal on the Macintosh. On the PC and Unix, however, LabVIEW uses standard C calling conventions, so the header file declares the word CIN to be equivalent to nothing.

The `MgErr` data type is a LabVIEW data type corresponding to a set of error codes the manager routines return. If you call a manager routine that returns an error, you can either handle the error or return the error so LabVIEW can handle it. If you can handle the errors that occur, return the error code `noErr`.

After calling a CIN routine, LabVIEW checks the `MgErr` value to determine whether an error occurred. If an error occurs, LabVIEW aborts the VI containing the CIN. If the VI is a subVI, LabVIEW aborts the VI containing the subVI. This behavior enables LabVIEW to handle conditions when a VI runs out of memory. By aborting the running VI, LabVIEW can possibly free enough memory to continue running correctly.

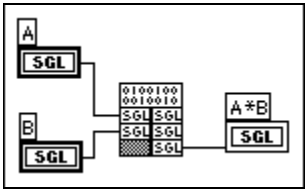
Examples with Scalars

The following examples show the steps for creating CINs and how to work with scalar data types. Chapter 5, *Manager Overview*, contains more examples.

Creating a CIN That Multiplies Two Numbers

Consider a CIN that takes two single-precision floating-point numbers and returns their product.

1. Place the CIN on the block diagram.
2. Add two input and output terminals to the CIN.
3. Place two single-precision numeric controls and one single-precision numeric indicator on a front panel. Wire the node as shown in the following illustration. Notice **A*B** is wired to an output-only terminal pair.



Save the VI as `mult.vi`.

4. Select **Create .c File...** from the CIN node pop-up menu. LabVIEW prompts you to select a name and a storage location for a `.c` file. Name the file `mult.c`. LabVIEW creates a `.c` file shown in the following listing.

```
/*
 * CIN source file
 */

#include "extcode.h"

CIN MgErr CINRun (float32 *A, float32 *B,
float32 *A_B);

CIN MgErr CINRun (float32 *A, float32 *B,
float32 *A_B) {

   /* ENTER YOUR CODE HERE */

   return noErr;

   }
```

This .c file contains a prototype and a template for the CIN's CINRun routine. LabVIEW calls the CINRun routine when the CIN executes. In this example, LabVIEW passes CINRun the addresses of the three 32-bit floating-point numbers. The parameters are listed left to right in the same order as you wired them (top to bottom) to the CIN. Thus, A, B, and A_B are pointers to **A**, **B**, and **A*B**, respectively.

As described in the *CIN .c File* section of this chapter, the float32 data type is not a standard C data type. When LabVIEW creates a .c file, it gives unambiguous names for data types. For most C compilers, the float32 data type corresponds to the float data type. However, this may not be true in all cases, because the C standard does not define the sizes for the various data types. You can use these LabVIEW data types in your code because extcode.h associates these data types with the corresponding C data type for the compiler you are using. In addition to defining LabVIEW data types, extcode.h also prototypes LabVIEW routines you can access. These data types and routines are described in Chapter 5, *Manager Overview*, of this manual and in the *CIN Function Overview* section of the LabVIEW *Online Reference*.

Note ***The line*** `#include "extcode.h"` ***must be a full pathname to*** `extcode.h` ***under THINK C. For example:*** `#include "harddrive:cintools:extcode.h"`

Optionally, System 7.x users can use the `Aliases` ***folder technique described in the THINK C for 68K (Version 7) subsection of Chapter 1, CIN Overview, to enable the include line to read*** `#include "extcode.h"`**.**

For this multiplication example, fill in the code for the CINRun routine. You do not have to use the variable names LabVIEW gives you in CINRun; you can change them to increase the readability of the code.

```
CIN MgErr CINRun (float32 *A, float32 *B,
float32 *A_B);
    {
    *A_B = *A * *B;
    return noErr;
    }
```

CINRun multiplies the values to which A and B refer and stores the results in the location to which A_B refers. It is important CIN routines return an error code, so LabVIEW knows if the CIN encountered any fatal problems and handles the error correctly.

If you return a value other than noErr, LabVIEW stops the execution of the VI.

5. After creating the source code, you need to compile it and convert it into a form LabVIEW can use. The following sections summarize the steps for each of the supported compilers.

Note ***Step 5 is different for each platform. Look under the heading for your platform and compiler in the following sections to find the instructions for your system. For details, refer to the relevant subsection within the Compile the CIN Source Code section in Chapter 1, CIN Overview.***

(THINK C for 68K and Symantec C++) Create a new project and place `mult.c` in it. Build `mult.lsb` according to the instructions in the *THINK C for 68K (Version 7)* or the *Symantec C++ 8.0 for Power Macintosh* of the *Compile the CIN Source Code* section of Chapter 1.

(Macintosh Programmer's Workshop for 68K and Power Macintosh) Create a file named `mult.lvm`. Make sure the name variable is set to `mult`. Build `mult.lvm` according to the instructions in the *Macintosh Programmer's Workshop for 68K and Power Macintosh* subsection of the *Compile the CIN Source Code* section of Chapter 1.

(Metrowerks CodeWarrior for Power Macintosh and 68K) Create a new project and place `mult.c` in it. Build `mult.lsb` according to the instructions in the *Metrowerks CodeWarrior for 68K* subsection of the *Compile the CIN Source Code* section of Chapter 1.

(Watcom C Compiler for Window 3.*x*) Create a file named `mult.lvm`. Make sure the name variable is set to `mult`. Build `mult.lvm` according to the instructions in the *Watcom C Compiler* subsection of the *Compile the CIN Source Code* section of Chapter 1.

(Microsoft Visual C++ Compiler Command Line and Symantec C for Windows 95 and Windows NT) Create a file named `mult.lvm`. Make sure the name variable is set to `mult`. Build `mult.lvm` according to the instructions in the *Visual C++ IDE* subsection of the *Compile the CIN Source Code* section of Chapter 1.

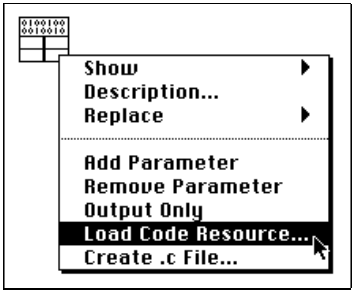
(Microsoft Visual C++ Compiler IDE for Windows 95 and Windows NT) Create a project according to the instructions in the *Visual C++ IDE* subsection of the *Compile the CIN Source Code* section of Chapter 1.

(All Unix Compilers) As described in the *Steps for Creating a CIN* section of Chapter 1, *CIN Overview*, you can create a makefile using the shell script `lvmkmf`. For this example, you should first enter the following command.

```
lvmkmf mult
```

This creates a file called `Makefile`. After executing `lvmkmf`, you should enter the standard `make` command, which uses `Makefile` to create a file called `mult.lsb`, which you can load into the CIN in LabVIEW.

6. Select **Load Code Resource** from the CIN pop-up menu and select `mult.lsb`, the object code file you created.

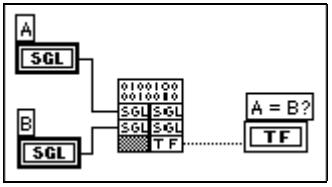


If you followed the preceding steps correctly, you should be able to run the VI at this point. If you save the VI, the CIN object code is saved along with the VI.

Comparing Two Numbers, Producing a Boolean Scalar

The following example shows how to create a CIN that compares two single-precision numbers. If the first number is greater than the second one, the return value is TRUE; otherwise, the return value is FALSE. This example gives only the block diagram and the code. Follow the instructions in the *Steps for Creating a CIN* section of Chapter 1 to create the CIN.

The diagram for this CIN is shown in the following illustration. Save the VI as `aequalb.vi`.



Create a `.c` file for the CIN, and name it `aequalb.c`. The `.c` file LabVIEW creates is as follows.

```
/*
 * CIN source file
 */

#include "extcode.h"

CIN MgErr CINRun(float32 *ap, float32 *bp,
LVBoolean *aequalbp);

CIN MgErr CINRun(float32 *ap, float32 *bp,
LVBoolean *aequalbp) {
    if (*ap == *bp)
        *aequalbp= LVTRUE;
    else
        *aequalbp= LVFALSE;
    return noErr;
    }
```

How LabVIEW Passes Variably Sized Data to CINs

LabVIEW allocates memory for arrays and strings dynamically. If a string or array needs more space to hold new data, its current location may not offer enough contiguous space to hold the resulting string or array. In this case, LabVIEW may have to move the data to a location that offers more space.

To accommodate this relocation of memory, LabVIEW uses handles to refer to the storage location of variably sized data. A handle is a pointer to a pointer to the desired data. LabVIEW uses handles instead of simple pointers because handles allow LabVIEW to move the data without invalidating references from your code to the data. If LabVIEW moves the data, LabVIEW updates the intermediate pointer to reflect the new location. If you use the handle, references to the data go through the intermediate pointer, which always reflects the correct location of the data. Handles are described in detail in Chapter 5, *Manager Overview*. Information about specific handle functions is available in the *CIN Function Overview* section of the LabVIEW *Online Reference*.

Alignment Considerations

When a CIN returns variably sized data, you need to adjust the size of the handle that references the array. One method of adjusting the handle size is to use the memory manager routine `DSSetHandleSize` or, if the data is stored in the application zone, the `AZSetHandleSize` routine, to adjust the size of the return data handle. Both techniques work, but they are trouble-prone because you have to calculate the size of the new handle correctly. It is difficult to calculate the size correctly in a platform-independent manner, however, because some platforms have special requirements about how you align and pad memory.

Instead of using *XX*`SetHandleSize`, use the LabVIEW routines that take this alignment into account when resizing handles. You can use the `SetCINArraySize` routine to resize a string or an array of arbitrary data type. This function is described in the *Resizing Arrays and Strings* section of this chapter.

If you are not familiar with alignment differences for various platforms, the following examples highlight the problem. Keep in mind `SetCINArraySize` and `NumericArrayResize` take care of these issues for you.

Consider the case of a 1D array of double-precision numbers. On the PC, an array of double-precision floating-point numbers is stored in a handle, and the first four bytes describe the number of elements in the array. These four bytes are followed by the 8-byte elements that make up the array. On the Sun, double-precision floating-point numbers must be aligned to 8-byte boundaries—the 4-byte value is followed by four bytes of *padding*. This padding ensures the array data falls on eight-byte boundaries.

As a more complicated example, consider a three-dimensional array of clusters, in which each cluster contains a double-precision floating-point number and a 4-byte integer. As in the previous example, the Sun stores this array in a handle. The first 12 bytes contain the number of pages, rows, and columns in the array. These dimension fields are followed by four bytes of filler (which ensures the first double-precision number is on an 8-byte boundary) and then the data. Each element contains eight bytes for the double-precision number, followed by four bytes for the integer. Each cluster is followed by four bytes of *padding*, which ensures the next element is properly aligned.

Arrays and Strings

LabVIEW passes arrays by handle, as described in the *Alignment Considerations* section of this chapter. For an *n*-dimensional array, the handle begins with *n* 4-byte values describing the number of values stored in a given dimension of the array. Thus, for a one-dimensional array, the first four bytes indicate the number of elements in the array. For a two-dimensional array, the first four bytes indicate the number of rows, and the second four bytes indicate the number of columns. These dimension fields can be followed by filler and then the actual data. Each element can also have padding to meet alignment requirements.

LabVIEW stores strings and Boolean arrays in memory as one-dimensional arrays of unsigned 8-bit integers.

☞ **Note** ***LabVIEW 4.x stored Boolean arrays in memory as a series of bits packed to the nearest 16-bit word. LabVIEW 4.x ignored unused bits in the last word. LabVIEW 4.x ordered the bits from left to right; that is, the most significant bit (MSB) is index 0. As with other arrays, a 4-byte dimension size preceded Boolean arrays. The dimension size for LabVIEW 4.x Boolean arrays indicates the number of valid bits contained in the array.***

Paths (Path)

The exact structure for `Path` data types is subject to change in future versions of LabVIEW. A `Path` is a dynamic data structure LabVIEW passes the same way it passes arrays. LabVIEW stores the data for `Paths` in an application zone handle. For more information about the functions that manipulate `Paths`, refer to the *CIN Function Overview* section of the LabVIEW *Online Reference*.

Clusters Containing Variably Sized Data

For cluster arguments, LabVIEW passes a pointer to a structure containing the elements of the cluster. LabVIEW stores scalar values directly as components inside the structure. If a component is another cluster, LabVIEW stores this cluster value as a component of the main cluster. If a component is an array or string, LabVIEW stores a handle to the array or string component in the structure.

Resizing Arrays and Strings

You can use the LabVIEW `SetCINArraySize` routine to resize return arrays and strings you pass to a CIN. You pass to the function the handle you want to resize, information describing the data structure, and the desired size of the array or handle. The function takes into account any padding and alignment needed for the data structure. The function does not, however, update the dimension fields in the array. If you successfully resize the array, you need to update the dimension fields to correctly reflect the number of elements in the array.

You can resize numeric arrays more easily with `NumericArrayResize`. You pass to this function the array you want to resize, a description of the data structure, and information about the new size of the array.

When you resize arrays of variably-sized data (for example, arrays of strings) with the `SetCINArraySize` or `NumericArrayResize` routines, you should be aware of the following facts. If the new size of the array is smaller, LabVIEW disposes of the handles used by the disposed element. Neither function sets the dimension field of the array. You must do this in your code after the function call. If the new size is larger, however, LabVIEW does not automatically create the handles for the new elements. You have to create these handles after the function returns.

The `SetCINArraySize` and `NumericArrayResize` functions are described in the following sections.

SetCINArraySize

syntax `MgErr SetCINArraySize (UHandle dataH, int32 paramNum, int32 newNumElmts);`

`SetCINArraySize` resizes a data handle based on the data structure of an argument you pass to the CIN. It does not set the array dimension field.

Parameter	Type	Description
dataH	UHandle	The handle you want to resize.
paramNum	int32	The number for this parameter in the argument list to the CIN. The leftmost parameter has a parameter number of 0, and the rightmost has a parameter number of n – 1, where n is the total number of parameters
newNumElmts	int32	The new number of elements to which the handle should refer. For a one-dimensional array of five values, you pass a value of 5 for this argument. For a two-dimensional array of two rows by three columns, you pass a value of 6 for this argument.

returns `MgErr`, which can contain the errors in the following list. `MgErrs` are discussed in Chapter 5, *Manager Overview*.

Error	Description
noErr	No error.
mFullErr	Not enough memory to perform operation
mZoneErr	Handle is not in specified zone.

NumericArrayResize

syntax `MgErr NumericArrayResize(int32 typeCode, int32 numDims, UHandle *dataHP, int32 totalNewSize);`

`NumericArrayResize` resizes a data handle referring to a numeric array. This routine also accounts for alignment issues. It does not set the array dimension field. If ***dataHP** is `NULL`, LabVIEW allocates a new array handle in ***dataHP**.

Parameter	Type	Description
typeCode	`int32`	Describes the data type for the array you want to resize. The header file `extcode.h` defines the following constants for this argument `iB` Data is an array of signed 8-bit integers. `iW` is an array of signed 16-bit integers. `iL` Data is an array of signed 32-bit integers. `uB` Data is an array of unsigned 8-bit integers. `uW` Data is an array of unsigned 16-bit integers. `uL` Data is an array of unsigned 32-bit integers. `fS` Data is an array of single-precision (32-bit) numbers. `fD` Data is an array of double-precision (64-bit) numbers. `fX` Data is an array of extended- precision numbers. `cS` Data is an array of single-precision complex numbers. `cD` Data is an array of double-precision complex numbers. `cX` Data is an array of extended-precision complex numbers.

Parameter	Type	Description
numDims	`int32`	The number of dimensions in the data structure to which the handle refers. Thus, if the handle refers to a two-dimensional array, you pass a value of 2 for **numDims**.
***dataHP**	`UHandle`	A pointer to the handle you want to resize. If this is a pointer to `NULL`, LabVIEW allocates and sizes a new handle appropriately and returns the handle in ***dataHP**.
totalNewSize	`int32`	The new number of elements to which the handle should refer. For a unidimensional array of five values, you pass a value of 5 for this argument. For a two-dimensional array of two rows by three columns, you pass a value of 6 for this argument.

returns `MgErr`, which can contain the errors in the following list.

Error	Description
noErr	No error.
mFullErr	Not enough memory to perform operation.
mZoneErr	Handle is not in specified zone.

Examples with Variably Sized Data

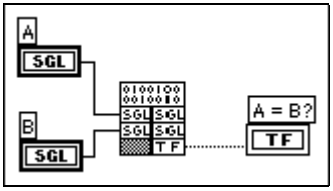
The following examples show the steps for creating CINs and how to work with variably-sized data types.

Concatenating Two Strings

The following example shows how to create a CIN that concatenates two strings. This example also shows how to use input-output terminals by passing the first string as an input-output parameter to the CIN. The top right terminal of the CIN returns the result of the concatenation.

This example gives only the diagram and the code. Follow the instructions in Chapter 1, *CIN Overview*, to create this CIN.

The diagram for this CIN is shown in the following illustration. Save the VI as `lstrcat.vi`.



Create a `.c` file for the CIN, and name it `lstrcat.c`. The `.c` file LabVIEW creates is as follows.

```
/*
 * CIN source file
 */

#include "extcode.h"

CIN MgErr CINRun(
    LStrHandle var1,
    LStrHandle var2);

CIN MgErr CINRun(
    LStrHandle var1,
    LStrHandle var2) {

    /* ENTER YOUR CODE HERE */

    return noErr;
    }
```

Now fill in the CINRun function as follows:

```
CIN MgErr CINRun(
    LStrHandle strh1,
    LStrHandle strh2) {
    int32 size1, size2, newSize;
    MgErr err;

    size1 = LStrLen(*strh1);
    size2 = LStrLen(*strh2);
    newSize = size1 + size2;
    if(err = NumericArrayResize(uB, 1L,
        (UHandle*)&strh1, newSize))
            goto out;

    /* append the data from the second string to
        first string */
    MoveBlock(LStrBuf(*strh2),
            LStrBuf(*strh1)+size1, size2);

    /* update the dimension (length) of the
        first string */
    LStrLen(*strh1) = newSize;
out:
    return err;
    }
```

In this example, CINRun is the only routine that performs substantial operations. CINRun concatenates the contents of strh2 to the end of strh1, with the resulting string stored in strh1. Before performing the concatenation, you need to resize strh1 with the LabVIEW routine NumericArrayResize to hold the additional data.

If NumericArrayResize fails, it returns a non-zero value of type MgErr. In this case, NumericArrayResize could fail if LabVIEW does not have enough memory to resize the string. Returning the error code gives LabVIEW a chance to handle the error. If CINRun reports an error, LabVIEW aborts the calling VIs. Aborting the VIs may free up enough memory so LabVIEW can continue running.

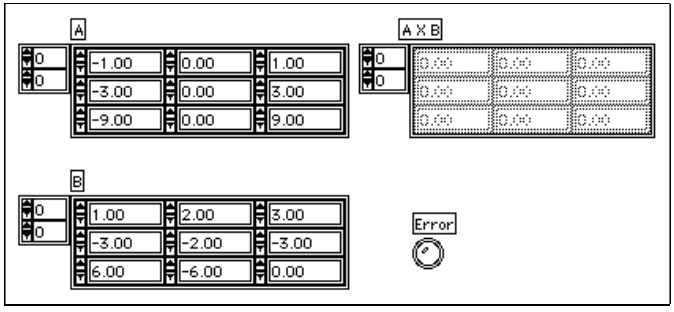
After resizing the string handle, this example copies the second string to the end of the first string using MoveBlock. MoveBlock is a support manager routine that moves blocks of data. Finally, this example sets the size of the first string to the length of the concatenated string.

Computing the Cross Product of Two Two-Dimensional Arrays

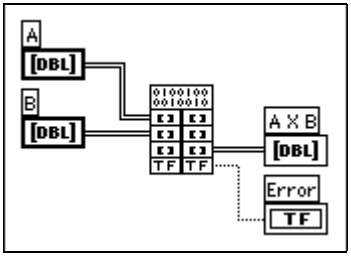
The following example shows how to create a CIN that accepts two two-dimensional arrays and then computes the cross product of the arrays. The CIN returns the cross product in a third parameter and a Boolean value as a fourth parameter. This Boolean is TRUE if the number of columns in the first matrix is not equal to the number of rows in the second matrix.

This example shows only the front panel, block diagram, and source code. Follow the instructions in the *Steps for Creating a CIN* section of Chapter 1, *CIN Overview*, to create the CIN.

The front panel for this VI is shown in the following illustration. Save the VI as `cross.vi`.



The block diagram for this VI is shown in the following illustration.



Save the `.c` file for the CIN as `cross.c`. Following is the source code for `cross.c` with the `CINRun` routine added.

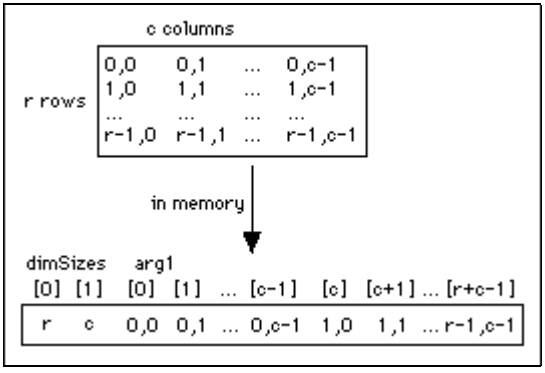
```
/*
 * CIN source file
 */

#include "extcode.h"
#define ParamNumber 2
   /* The return parameter is parameter 2 */
```

```
#define NumDimensions 2
   /* 2D Array */

/*
 * typedefs
 */

typedef struct {
   int32 dimSizes[2];
   float64 arg1[1];
   } TD1;
typedef TD1 **TD1Hdl;

CIN MgErr CINRun(TD1Hdl ah, TD1Hdl bh, TD1Hdl
result, LVBoolean *errorp);
CIN MgErr CINRun(TD1Hdl ah, TD1Hdl bh, TD1Hdl
result, LVBoolean *errorp) {
   int32        i,j,k,l;
   int32        rows, cols;
   float64      *aElmtp, *bElmtp, *resultElmtp;
   MgErr        err=noErr;
   int32        newNumElmts;

   if ((k = (*ah)->dimSizes[1]) !=
   (*bh)->dimSizes[0]) {
      *errorp = LVTRUE;
      goto out;
      }
   *errorp = LVFALSE;
   rows = (*ah)->dimSizes[0];
      /* number of rows in a and result */
   cols = (*bh)->dimSizes[1];
      /* number of cols in b and result */

   newNumElmts = rows * cols;
   if (err = SetCINArraySize((UHandle)result,
         ParamNumber, newNumElmts))
      goto out;

   (*result)->dimSizes[0] = rows;
   (*result)->dimSizes[1] = cols;

   aElmtp = (*ah)->arg1;
   bElmtp = (*bh)->arg1;
   resultElmtp = (*result)->arg1;

   for (i=0; i<rows; i++)
      for (j=0; j<cols; j++) {
         *resultElmtp = 0;
```

```
            for (l=0; l<k; l++)
                *resultElmtp += aElmtp[i*k + l] *
                        bElmtp[l*cos + j];
            resultElmtp++;
            }
out:
    return err;
    }
```

In this example, `CINRun` is the only routine performing substantial operations. `CINRun` cross multiplies the two-dimensional arrays `ah` and `bh`. LabVIEW stores the resulting array in `resulth`. If the number of columns in `ah` is not equal to the number of rows in `bh`, `CINRun` sets `*errorp` to `LVTRUE` to inform the calling diagram of invalid data.

`SetCINArraySize`, the LabVIEW routine that accounts for alignment and padding requirements, resizes the array. Notice the two-dimensional array data structure is the same as the one-dimensional array data structure, except the 2D array has two dimension fields instead of one. The two dimensions indicate the number of rows and the number of columns in the array, respectively. The data is declared as a one-dimensional C-style array. LabVIEW stores data row by row, as shown in the following illustration.



For an array with `r` rows and `c` columns, you can access the element at row `i` and column `j` as shown in the following code fragment.

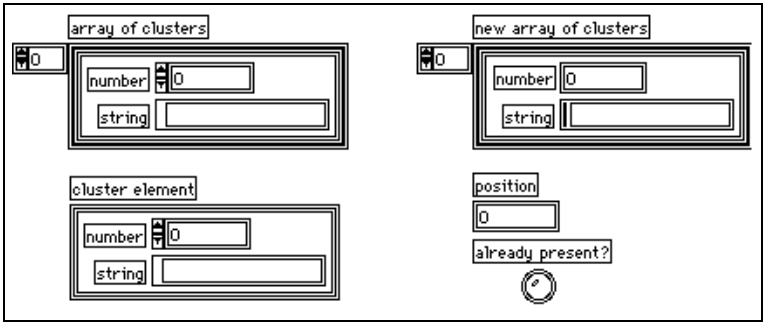
```
value = (*arrayh)->arg1[i*c + j];
```

Working with Clusters

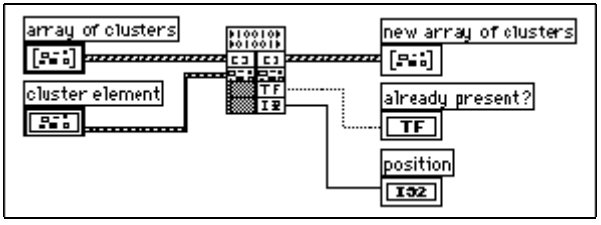
The following example takes an array of clusters and a single cluster as inputs, and the clusters contain a signed 16-bit integer and a string. The input for the array of clusters is an input-output terminal. In addition to the array of clusters, the CIN returns a Boolean and a signed 32-bit integer. If the cluster value is already present in the array of clusters, the CIN sets the Boolean to TRUE and returns the position of the cluster in the array of clusters using the 32-bit integer output. If the cluster value is not present, the CIN adds it to the array, sets the Boolean output to FALSE, and returns the new position of the cluster in the array of clusters.

This example shows only the front panel, block diagram, and source code. Follow the instructions in the *Steps for Creating a CIN* section of Chapter 1, *CIN Overview*, to create the CIN.

The front panel for this VI is shown in the following illustration. Save the VI as `tblsrch.vi`.



The block diagram for this VI is shown in the following illustration:



Save the .c file for the CIN as tblsrch.c. Following is the source code for tblsrch.c with the CINRun routine added:

```
/*
 * CIN source file
 */

#include "extcode.h"

#define ParamNumber 0
   /* The array parameter is parameter 0 */

/*
 * typedefs
 */

typedef struct {
   int16 number;
   LStrHandle string;
   } TD2;

typedef struct {
   int32 dimSize;
   TD2 arg1[1];
   } TD1;
typedef TD1 **TD1Hdl;

CIN MgErr CINRun(
                TD1Hdl       clusterTableh,
                TD2          *elementp,
                LVBoolean    *presentp,
                int32        *positionp);

CIN MgErr CINRun(
                TD1Hdl       clusterTableh,
                TD2          *elementp,
                LVBoolean    *presentp,
                int32        *positionp) {

   int32        size,i;
   MgErr        err=noErr;
   TD2          *tmpp;
   LStrHandle   newStringh;
   TD2          *newElementp;
   int32        newNumElements;

   size = (*clusterTableh)->dimSize;
   tmpp = (*clusterTableh)->arg1;

   *positionp = -1;
   *presentp = LVFALSE;
```

```
    for(i=0; i<size; i++) {
        if(tmpp->number == elementp->number)
            if(LStrCmp(*(tmpp->string),
                       *(elementp->string)) == 0)
                break;
        tmpp++;
        }
    if(i<size) {
        *positionp = i;
        *presentp = LVTRUE;
        goto out;
        }
    newStringh = elementp->string;
    if(err = DSHandToHand((UHandle *)
    &newStringh))
        goto out;
    newNumElements = size+1;
    if(err =
        SetCINArraySize((UHandle)clusterTableh,
        ParamNumber,
        newNumElements)) {
        DSDisposeHandle(newStringh);
        goto out;
        }
    (*clusterTableh)->dimSize = size+1;
    newElementp = &((*clusterTableh)
    ->arg1[size]);
    newElementp->number = elementp->number;
    newElementp->string = newStringh;
    *positionp = size;
out:
    return err;
    }
```

In this example, `CINRun` is the only routine performing substantial operations. `CINRun` first searches through the table to see if the element is present. `CINRun` then compares string components using the LabVIEW routine `LStrCmp`, which is described in the *CIN Function Overview* section of the LabVIEW *Online Reference*. If `CINRun` finds the element, the routine returns the position of the element in the array.

If the routine does not find the element, you have to add a new element to the array. Use the memory manager routine `DSHandToHand` to create a new handle containing the same string as the one in the cluster element you passed to the CIN. `CINRun` then increases the size of the array using `SetCINArraySize` and fills the last position with a copy of the element you passed to the CIN.

If the `SetCINArraySize` call fails, the CIN returns the error code returned by the manager. If the CIN is unable to resize the array, LabVIEW disposes of the duplicate string handle.

3

CIN Advanced Topics

This chapter covers several topics needed only in advanced applications, including how to use the `CINInit`, `CINDispose`, `CINAbort`, `CINLoad`, `CINUnload`, `CINSave`, and `CINProperties` routines. The chapter also discusses how global data works within CIN source code, and how users of Windows 3.1, Windows 95, and Windows NT can call a DLL from a CIN.

CIN Routines

A CIN consists of several routines, as described by the `.c` file LabVIEW creates when you select **Create .c File...** from the CIN pop-up menu. The previous chapters have discussed only the `CINRun` routine. The other routines are `CINLoad`, `CINInit`, `CINAbort`, `CINSave`, `CINDispose`, `CINUnload`, and `CINProperties`.

It is important to understand that for most CINs, you need to write only the `CINRun` routine. The other routines are supplied mainly for the cases in which you have special initialization needs, such as when your CIN is going to maintain some information across calls, and you want to preallocate or initialize global state information.

In the case where you want to preallocate/initialize global state information, you first need to understand more of how LabVIEW manages data and CINs.

Data Spaces and Code Resources

When you create a CIN, you compile your source into an object code file and load the code into the node. At that point, LabVIEW loads a copy of the code (called a code resource) into memory and attaches it to the node. When you save the VI, this code resource is saved along with the VI as an attached component; the original object code file is no longer needed.

When LabVIEW loads a VI, it allocates a *data space*, a block of data storage memory, for that VI. This data space is used, for instance, to store the values in shift registers. If the VI is reentrant, then LabVIEW allocates a data space for each usage of the VI. See Chapter 26, *Understanding the*

Execution System, in your *G Programming Reference Manual* for more information on reentrancy.

Within your CIN code resource, you may have declared global data. Global data includes variables declared outside of the scope of all routines, and, for the purposes of this discussion, variables declared as static variables within routines. LabVIEW allocates space for this global data. As with the code itself, there is always only one instance of these globals in memory. Regardless of how many nodes reference the code resource and regardless of whether the surrounding VI is reentrant, there is only one copy of these globals in memory, and their values are consistent.

When you create a CIN node, LabVIEW allocates a *CIN data space*, a 4-byte storage location in the VI data space(s), strictly for the use of the CIN node. Each CIN may have one or more CIN data spaces reserved for the node, depending on how many times the node appears in a VI or collection of VIs. You can use this CIN data space to store global data on a per data space basis, as described in the *Code Globals and CIN Data Space Globals* section later in this chapter.

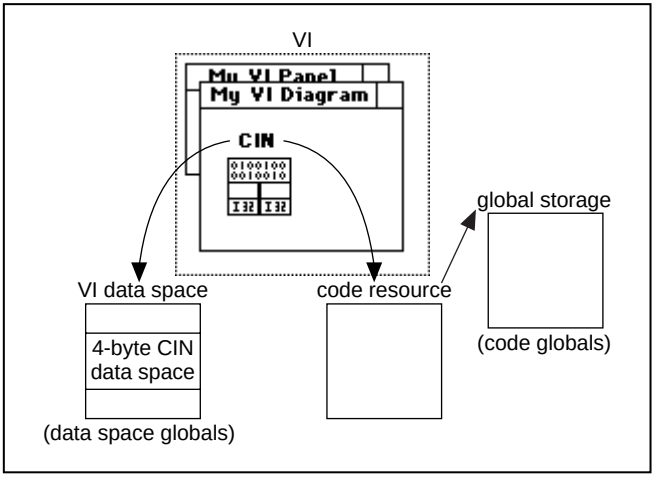


Figure 3-1. Data Storage Spaces for One CIN, Simple Case

A CIN node references the code resource by name, using the name you specified when you created the code resource. When you load a VI containing a CIN, LabVIEW looks in memory to see if a code resource with the desired name is already loaded. If so, LabVIEW links the CIN to the code resource for execution purposes.

This linking behaves the same way as links between VIs and subVIs. When you try to reference a subVI and another VI with the same name already exists in memory, LabVIEW references the one already in memory instead of the one you selected. In the same way, if you try to load references to two different code resources having the same name, only one code resource is actually loaded into memory, and both references point to the same code. The difference is that LabVIEW can verify a subVI call matches the subVI connector pane terminal, but LabVIEW cannot verify your source code matches the CIN call.

CIN Routines: The Basic Case

The following discussion describes what happens in the standard case, in which you have a code resource referenced by only one CIN, and the VI containing the CIN is non-reentrant. The other cases have slightly more complicated behavior, described in later sections of this chapter.

Loading a VI

When you first load a VI, LabVIEW calls the `CINLoad` routines for any CINs contained in that VI. This gives you a chance to load any file-based resources at load time, because LabVIEW calls this routine only when the VI is first loaded (see the *Loading a New Resource into the CIN* section that follows for an exception to this rule). After LabVIEW calls the `CINLoad` routine, it calls `CINInit`. Together, these two routines perform any initialization you need before the VI runs.

LabVIEW calls `CINLoad` once for a given code resource, regardless of the number of data spaces and the number of references to that code resource. This is why you should initialize code globals in `CINLoad`.

LabVIEW calls `CINInit` for a given code resource a total of one time for each CIN data space multiplied by the number of references to the code resource in the VI corresponding to that data space. If you want to use CIN data space globals, you should initialize them in `CINInit`. See the *Code Globals and CIN Data Space Globals*, the *Loading a New Resource into the CIN*, and the *Compiling a VI* sections of this chapter for related information.

Unloading a VI

When you close a VI front panel, LabVIEW checks to see if there are any references to that VI in memory. If so, then the VI code and data space remain in memory. When all references to a VI are removed from memory, and its front panel is not open, that VI is unloaded from memory.

When a VI is unloaded from memory, LabVIEW calls the `CINDispose` routine, giving you a chance to dispose of anything you allocated earlier. `CINDispose` is called for each `CINInit` call. For instance, if you used `XXNewHandle` in your `CINInit` routine, you should use `XXDisposeHandle` in your `CINDispose` routine. LabVIEW calls `CINDispose` for a code resource once for each individual CIN data space.

As the last reference to the code resource is removed from memory, LabVIEW calls the `CINUnload` routine for that code resource once, giving you the chance to dispose of anything allocated in `CINLoad`. As with `CINDispose/CINInit`, a `CINUnload` is called for each `CINLoad`. For example, if you loaded some resources from a file in `CINLoad`, you can free the memory those resources are using in `CINUnload`. After LabVIEW calls `CINUnload`, the code resource itself is unloaded from memory.

Loading a New Resource into the CIN

If you load a new code resource into a CIN, the old code resource is first given a chance to dispose of anything it needs to dispose. First, LabVIEW calls `CINDispose` for each CIN data space and each reference to the code resource, followed by the `CINUnload` for the old resource. The new code resource is then given a chance to perform any initialization it needs to perform: LabVIEW calls the `CINLoad` for the new code resource, followed by the `CINInit` routine, called once for each data space and each reference to the code resource.

Compiling a VI

When you compile a VI, LabVIEW recreates the VI data space, resetting all uninitialized shift registers, for instance, to their default values. In the same way, your CIN is given a chance to dispose or initialize any storage it manages. Before disposing of the current data space, LabVIEW calls the `CINDispose` routine for each reference to the code resource within the VI(s) being compiled to give the code resource a chance to dispose of any old results it is managing. LabVIEW then compiles the VI and creates a new data space for the VI(s) being compiled (multiple data spaces for any reentrant VI). The `CINInit` routine is then called for each reference to the

code resource within the compiled VI(s) to give the code resource a chance to create or initialize any data it wants to manage.

Running a VI

When you press the Run button of a VI, the VI begins to execute. When LabVIEW encounters a code interface node, it calls the `CINRun` routine for that node.

Saving a VI

When you save a VI, LabVIEW calls the `CINSave` routine for that VI, giving you the chance to save any resources (for example, something you loaded in `CINLoad`). Notice when you save a VI, LabVIEW creates a new version of the file, even if you are saving the VI with the same name. If the save is successful, LabVIEW deletes the old file and renames the new file with the original name. Therefore, anything you expect to be able to load in `CINLoad` needs to be saved in `CINSave`.

Aborting a VI

When you abort a VI, LabVIEW calls the `CINAbort` routine for every reference to a code resource contained in the VI being aborted. The `CINAbort` routine of all actively running subVIs is also called. If a CIN is in a reentrant VI, it is called for each CIN data space as well. CINs in VIs not currently executing are not notified by LabVIEW of the abort event.

CINs are synchronous. When a CIN begins execution, it takes over control of its thread until the CIN completes. If your version of LabVIEW is single-threaded, LabVIEW is not notified if the user clicks on the abort button and therefore cannot abort the CIN. No other LabVIEW tasks can execute while a CIN executes.

Multiple References to the Same CIN in a Single VI

If you have loaded the same code resource into multiple CINs, or you have duplicated a given code interface node, LabVIEW gives each reference to the code resource a chance to perform initialization or deallocation. No matter how many references you have in memory to a given code resource, the LabVIEW calls the `CINLoad` routine only once when the resource is first loaded into memory (though it is also called if you load a new version of the resource, as described in the previous section). When you unload the VI, LabVIEW calls `CINUnload` once.

After LabVIEW calls `CINLoad`, it calls `CINInit` once for each reference to the CIN, because its CIN data space may need initialization. Thus, if you have two nodes in the same VI, where both reference the same code, the LabVIEW calls the `CINLoad` routine once, and the `CINInit` twice. If you later load another VI referencing the same code resource, then LabVIEW calls `CINInit` again for the new version. LabVIEW has already called `CINLoad` once, and does not call it again for this new reference.

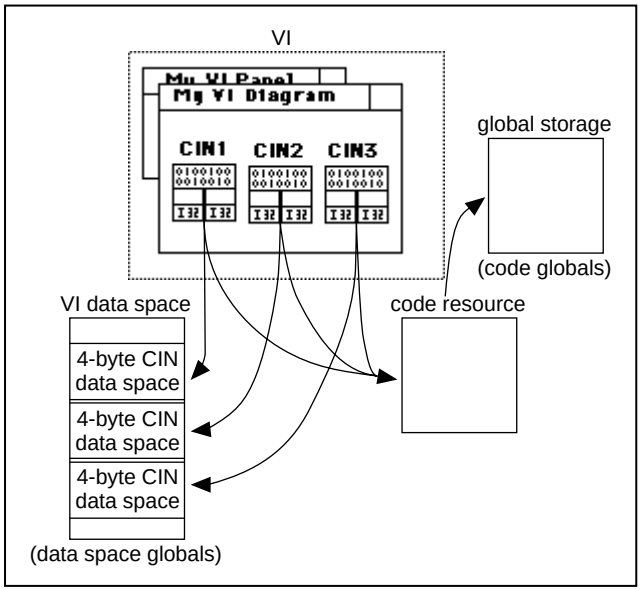


Figure 3-2. Three CINs Referencing the Same Code Resource

LabVIEW calls `CINDispose` and `CINAbort` for each individual CIN data space. LabVIEW calls `CINSave` only once, regardless of the number of references to a given code resource within the VI you are saving.

Multiple Reference to the same CIN in different VIs

Making multiple references to the same CIN in different VIs is different for single threaded operating systems than it is for mutlithreaded operating systems. To take advantage of multithreading, you must use LabVIEW 5.*x* on an operating system supporting it: Windows 95, Windows NT, Solaris 2.*x*, and Concurrent PowerMAX.

Single Threaded Operating Systems

When you make a VI reentrant, LabVIEW creates a separate data space for each usage of that VI. If you have a CIN data space in a reentrant VI and you call that VI in seven places, LabVIEW allocates memory to store seven CIN data spaces for that VI, each of which contains a unique storage location for the CIN data space for that calling instance.

As with multiple instances of the same node, LabVIEW calls the `CINInit`, `CINDispose`, and `CINAbort` routines for each individual CIN data space.

In the case where you have a reentrant VI containing multiple copies of the same code resource, LabVIEW calls the `CINInit`, `CINDispose`, and `CINAbort` routines once for each use of the reentrant VI, multiplied by the number of references to the code resource within that VI.

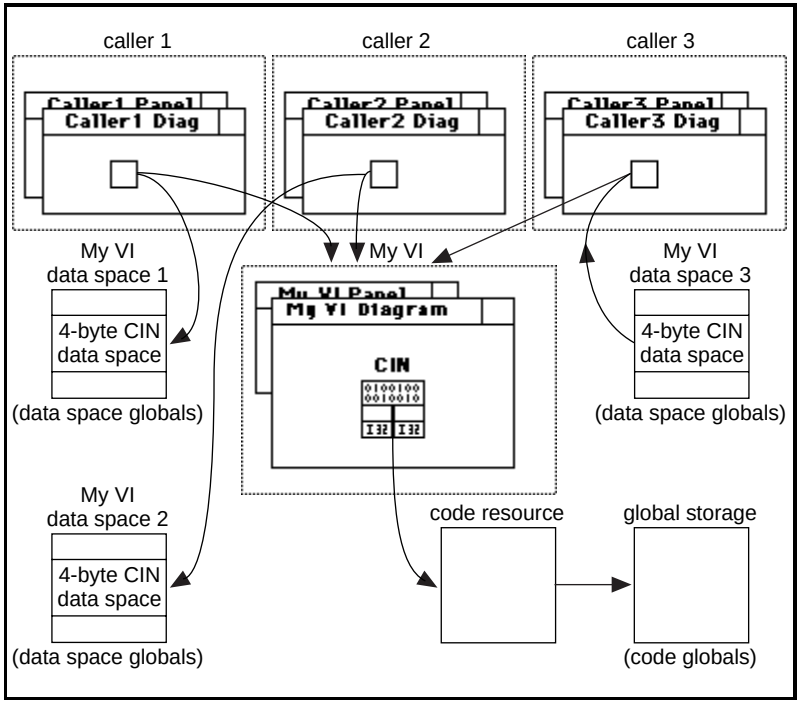


Figure 3-3. Three VIs Referencing a Reentrant VI Containing One CIN

Multithreaded Operating Systems

By default, CINs written before LabVIEW 5.0 run in a single thread, the user interface thread. When you change a CIN to be reentrant (execute in multiple threads), more than one execution thread can call the CIN at the same time. If you want a CIN to run in the diagram's current execution thread, add the following code to your .c file:

```
CIN MgErr CINProperties(int32 mode, void *data)
   {
   switch (mode) {
      case kCINIsReentrant:
         *(Bool32 *)data = TRUE;
         return noErr;
         break;
      }
   return mgNotSupported;
   }
```

If you read and write a global or static variable or call a non-reentrant function within your CINs, keep the execution of those CINs in a single thread. Even if a CIN is marked reentrant, the CIN functions other than `CINRun` are called from the user interface thread. This means `CINInit` and `CINDispose`, for example, are never called from two different threads at the same time, but `CINRun` might be running when the user interface thread is calling `CINInit`, `CINAbort`, or any of the other functions.

To be reentrant, the CIN must be safe to call `CINRun` from multiple threads, and safe to call any of the other `CIN`... procedures and `CINRun` at the same time. Other than `CINRun`, you do not need to protect any of the `CIN`... procedures from each other, because calls to them are always in one thread.

Code Globals and CIN Data Space Globals

When you declare global or static local data within a CIN code resource, LabVIEW allocates storage for that data. LabVIEW maintains your globals across calls to various routines.

When you allocate a global in a CIN code resource, LabVIEW creates storage for only one instance of it, regardless of whether the CIN's VI is reentrant or whether you have multiple references to the same code resource in memory.

In some cases, you may want globals for each reference to the code resource multiplied by the number of usages of the VI (if the VI is reentrant). For each instance of one of these globals, LabVIEW allocates the CIN data space for the use of the code interface node. Within the `CINInit`, `CINDispose`, `CINAbort`, and `CINRun` routines you can call the `GetDSStorage` routine to retrieve the value of the CIN data space for the current instance. You can also call `SetDSStorage` to set the value of the CIN data space for this instance.

You can use this storage location to store any 4-byte quantity you want to have for each instance of one of these globals. If you need more than four bytes of global data, you can store a handle or pointer to a structure containing your globals.

The following two lines of code are examples of the exact syntax of these two routines, defined in `extcode.h`.

```
int32 GetDSStorage(void);
```

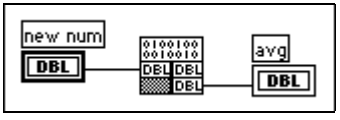
This routine returns the value of the 4-byte quantity in the CIN data space LabVIEW allocates for each CIN code resource, or for each use of the surrounding VI (if the VI is reentrant). You should call this routine only from `CINInit`, `CINDispose`, `CINAbort`, or `CINRun`.

```
int32 SetDSStorage(int32 newVal);
```

This routine sets the value of the 4-byte quantity in the CIN data space LabVIEW allocates for each CIN use of that code resource, or the uses of the surrounding VI, (if the VI is reentrant). It returns the old value of the 4-byte quantity in that CIN data space. Call this routine only from `CINInit`, `CINDispose`, `CINAbort`, or `CINRun`.

Examples

The following two examples illustrate the differences between code globals and CIN data space globals. In both examples, the CIN takes a number and returns the average of that number and the previous numbers passed to it.



When you design your code, decide whether it is appropriate to use code globals or data space globals. If you use code globals, calling the same code resource from multiple nodes or different reentrant VIs will affect the same set of globals. In the code globals averaging example, the result will indicate the average of all values passed to the CIN.

If you use CIN data space globals, each CIN calling the same code resource and each VI can have its own set of globals, if the VI is reentrant. In the CIN data space averaging example, the results would indicate the average of values passed to a specific node for a specific data space.

If you have only one CIN referencing the code resource, and the VI containing that CIN is not reentrant, it does not matter which method you choose.

Using Code Globals

The following code implements averaging using code globals. Notice the variables are initialized in `CINLoad`. If the variables are dynamically created (if they are pointers or handles), you can allocate the memory for the pointer or handle in `CINLoad`, and deallocate it in `CINUnload`. You can do this because `CINLoad` and `CINUnload` are called only once, regardless of the number of references to the code resources and the number of data spaces. Notice the `UseDefaultCINLoad` macro is not used, because this `.c` file has a `CINLoad` function.

```
/*
 * CIN source file
 */

#include "extcode.h"

float64 gTotal;
int32 gNumElements;

CIN MgErr CINRun(float64 *new_num, float64 *avg);

CIN MgErr CINRun(float64 *new_num, float64 *avg)
   {
   gTotal += *new_num;
   gNumElements++;
   *avg = gTotal / gNumElements;
   return noErr;
   }

CIN MgErr CINLoad(RsrcFile rf)
   {
   gTotal=0;
   gNumElements=0;
   return noErr;
   }
```

Using CIN Data Space Globals

The following is an alternative implementation of averaging using CIN data space globals. A handle for the global data is allocated in `CINInit`, and stored in the CIN data space storage using `SetDSStorage`. When LabVIEW calls the `CINInit`, `CINDispose`, `CINAbort`, or `CINRun` routines, it ensures `GetDSStorage` and `SetDSStorage` will return the 4 byte CIN data space value for that node or CIN data space.

When you want to access that data, use `GetDSStorage` to retrieve the handle and then dereference the appropriate fields (see the code for `CINRun` in the following example). Finally, in your `CINDispose` routine you need to dispose of the handle.

```
/*
 * CIN source file
 */

#include "extcode.h"

typedef struct {
   float64      total;
   int32        numElements;
   } dsGlobalStruct;

CIN MgErr CINInit() {
   dsGlobalStruct **dsGlobals;
   MgErr err = noErr;

   if (!(dsGlobals = (dsGlobalStruct **)
          DSNewHandle(sizeof(dsGlobalStruct))))
   {
   /* if 0, ran out of memory */
      err = mFullErr;
      goto out;
      }

   (*dsGlobals)->numElements=0;
   (*dsGlobals)->total=0;

   SetDSStorage((int32) dsGlobals);
out:
   return noErr;
   }

CIN MgErr CINDispose()
{
   dsGlobalStruct **dsGlobals;

   dsGlobals=(dsGlobalStruct **) GetDSStorage();
```

```
    if (dsGlobals)
        DSDisposeHandle(dsGlobals);

    return noErr;
    }
CIN MgErr CINRun(float64 *new_num, float64 *avg);
CIN MgErr CINRun(float64 *new_num, float64 *avg)
    {
    dsGlobalStruct **dsGlobals;

    dsGlobals=(dsGlobalStruct **) GetDSStorage();

    if (dsGlobals) {
        (*dsGlobals)->total += *new_num;
        (*dsGlobals)->numElements++;
        *avg = (*dsGlobals)->total /
        (*dsGlobals)->numElements;

        }
    return noErr;
    }
```

Calling a Windows 95 or Windows NT Dynamic Link Library

No special techniques are necessary to call a Windows 95 or Windows NT DLL. Call DLLs the way you ordinarily would in a Windows 95 or Windows NT program.

Calling a Windows 3.1 Dynamic Link Library

Although dynamic link libraries (DLLs) can be called from a CIN, the method for doing so is somewhat cumbersome. The Call Library Function is a more convenient way to call a DLL, and the Watcom compiler is not required. For more information on the Call Library Function, see Chapter 13, *Advanced Functions*, in the *LabVIEW Function and VI Reference Manual*, and Chapter 25, *Calling Code from Other Languages*, in your *G Programming Reference Manual*.

Before you attempt to link a dynamic link library with a CIN, first write a C program calling it. Do this to ensure you are calling the DLL properly, and the DLL behaves as expected. You can test the C program using the debugging tools supplied by your compiler.

After you are sure the DLL works and you are calling it correctly, write the 32-bit CIN that LabVIEW can call. The main purpose of this CIN is to act as a go-between, translating LabVIEW 32-bit data to 16-bit data. This CIN will take 32-bit pointers from LabVIEW and then call the DLL with the appropriate arguments.

See the *Calling 16-bit DLLs* section of Chapter 37, *Programming Overview*, in the *Windows 32-bit Programming Guide* section of the *Watcom C/386 User's Guide* for a detailed discussion of how to call a 16-bit DLL.

No special techniques are necessary to call a Windows 95 or Windows NT DLL.

Calling a 16-Bit DLL

The following steps are a brief summary of how to call a 16-bit DLL from a CIN. If you are not familiar with the functions used in this example, you should refer to *Microsoft Windows Programmer's Reference* or the *Watcom C/386 User's Guide*.

1. Load the DLL

Load the DLL by calling the function `LoadLibrary()` with the name of the DLL. For example, the following code returns a handle to a specified library.

```
HANDLE hDLL;

hDLL = LoadLibrary("library name");
```

This is a standard Windows function, and is documented in the *Microsoft Windows Programmer's Reference*.

☞ **Note** ***If you do not specify a full path, Windows searches the Windows directory, the Windows system directory, the LabVIEW directory, and the directories listed in the*** `Path` ***variable.***

2. Get the address of the desired function

Call `GetProcAddress()` with the name of the function you want to call. For example, the following code returns the address of a specified function. This address is a 16-bit pointer, and cannot be called using standard DLL call methods. Instead you have to use the Watcom C method, shown as follows.

```
FARPROC lpfn;
lpfn = GetProcAddress(hDLL, "function name");
```

As with `LoadLibrary`, this function is a standard Windows function, and is documented in the *Microsoft Windows Programmer's Reference*.

3. Describe the function

Use `GetIndirectFunctionHandle()` to describe the function and the types of each parameter it accepts. This function uses the following format.

```
HINDIR GetIndirectFunctionHandle(FARPROC proc
          [, long param1type,long param2type,
          ...,] long terminator);
```

proc is the address of the function returned in step 2.

The **paramXtype** values should be one of the following five constants describing the parameters for the call to the function.

`INDIR_DWORD`	The parameter will be a long word value (a 32-bit integer).
`INDIR_WORD`	The parameter will be a word value (a 16-bit integer).
`INDIR_CHAR`	The parameter will be a byte value (an 8-bit integer).
`INDIR_PTR`	The parameter is a pointer. Watcom will automatically convert the 32-bit address to a 16-bit far pointer before calling the code. Notice this 16-bit pointer is good only for the duration of the call; after the function returns, the 16-bit reference to the data is no longer valid.

`INDIR_CDECL`	Make the call using Microsoft C calling conventions. This keyword can be present anywhere in the parameter list.

For **terminator**, pass a value of `INDIR_ENDLIST`, which marks the end of the parameter list.

`GetIndirectFunctionHandle()` returns a handle used when you want to call the function.

4. Call the function

Use `InvokeIndirectFunction()` to call the function. Pass it the handle returned in step 3, along with the arguments you want to pass to the CIN. This function uses the following format.

```
long InvokeIndirectFunction(HINDIR proc
          [, param1, param2, ...]);
```

proc is the address of the function returned in step 3. Following that are the parameters you want to pass to the DLL.

Example: A CIN that Displays a Dialog Box

You cannot call most Windows functions directly from a CIN. You can, however, call a DLL, which in turn can call Windows functions. The following example shows how to call a DLL from a CIN. The DLL calls the Windows `MessageBox` function, which displays a window containing a specified message. This function returns after the user presses a button in the window.

The DLL

Most Windows compilers can create a DLL. Regardless of the compiler you use to create a DLL, the way you call it from a CIN will be roughly the same. Because you must have Watcom C/386 to write a Windows CIN, the following example is for a Watcom DLL. The process for creating a DLL using the Watcom compiler is described in Chapter 38, *Windows 32-Bit Dynamic Link Libraries*, of the *Watcom C/386 User's Guide*.

The following code is for a Watcom C/386 32-bit DLL that calls the `MessageBox` function. The `_16MessageBox` function calls the Windows `MessageBox` function; the only difference between these functions is the former takes far 16-bit pointers, which are pointers passed to the DLL. In this 32-bit environment, `MessageBox` expects near 32-bit pointers.

Passing pointers to 32-bit DLLs is inherently tricky. In this example, a 32-bit near pointer is converted to a 16-bit far pointer and passed to MessageBox via _16MessageBox. You cannot dereference a 16-bit pointer directly in this DL—it must first be converted to a 32-bit pointer. These pointer issues are not related to LabVIEW, but are unique to the Windows 3.1 environment. It may be helpful to build a rudimentary 32-bit Windows application (in place of LabVIEW) calling the DLL to test the use of pointers.

The DLL function will accept two parameters. The first is the message to display in the window. The second is the title to display in the window. Both parameters are C strings, meaning they are pointers to the characters of the string, followed by a terminating null character. Save the code in a file called `MSGBXDLL.C`.

```
/*
 * MSGBXDLL.C
 */
#include <windows.h>
#include <dos.h>
void FAR PASCAL Lib1( LPSTR message,
          LPSTR winTitle)
   {
   _16MessageBox( NULL,
          message,
          winTitle,
          MB_OK | MB_TASKMODAL );
   }
int PASCAL WinMain( HANDLE hInstance,
          HANDLE x1,
          LPSTR lpCmdLine,
          int x2 )
   {
   DefineDLLEntry( 1,
          (void *) Lib1,
          DLL_PTR,
          DLL_PTR,
          DLL_ENDLIST );
   return( 1 );
   }
```

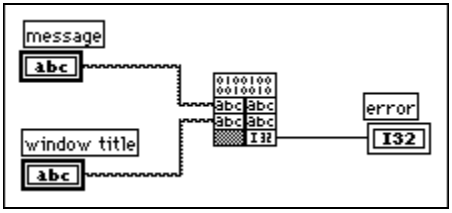
In addition to the C file, you also need to create the following `MSGBXDLL.LNK` file.

```
system win386
file msgbxdll
option map
option stack=12K
option maxdata=8K
option mindata=4K
```

Enter the following commands at the DOS prompt to create the DLL.

```
C>wcc386 msgbxdll /zw
C>wlink @msgbxdll
C>wbind msgbxdll –d –n
```

Following is the LabVIEW block diagram for a VI calling a CIN that calls the previously described DLL. It passes two LabVIEW strings to the CIN, and the CIN returns an error code.



The CIN Code

The following C code is for a CIN calling the DLL you created previously. This code assumes the `.h` file created by LabVIEW is named `msgbox.h`.

This example does not pass a full path to `LoadLibrary`. You should move the DLL to the top level of your LabVIEW directory so it will be found. See the note in the section *1. Load the DLL*, earlier in this chapter for more information.

```
/*
 * CIN source file
 */

#include "extcode.h"
#include "hosttype.h"
#include <windows.h>

CIN MgErr CINRun(LStrHandle message,
    LStrHandle winTitle,
```

```
int32 *err)
{
HANDLE        hDLL = NULL;
FARPROC       addr = NULL;
HINDIR        hMessageBox;
int           cb;
char          *messageCStr = NULL,
              *winTitleCStr = NULL;
MgErr         cinErr = noErr;

*err=0;
hDLL = LoadLibrary("msgbxdll.dll");
if (hDLL < HINSTANCE_ERROR) {
   *err = 1;/* LoadLibrary failed */
   goto out;
   }

addr = GetProcAddress(hDLL, "Win386LibEntry");
if (!addr) {
   *err = 2;/* GetProcAddress failed */
   goto out;
   }

hMessageBox = GetIndirectFunctionHandle(
              addr,
              INDIR_PTR,
              INDIR_PTR,
              INDIR_WORD,
              INDIR_ENDLIST );

if (!hMessageBox) {
   *err = 3; /* GetIndirectFunctionHandle
   failed */
   goto out;
   }

if (!(messageCStr =
   DSNewPtr(LStrLen(*message)+1))) {
   /* mem errs are serious-stop execution */
      cinErr=mFullErr;
      goto out;
   }

if (!(winTitleCStr =
   DSNewPtr(LStrLen(*winTitle)+1))) {
   /* mem errs are serious-stop execution */
      cinErr=mFullErr;
      goto out;
```

```
        }
    SPrintf(messageCStr, (CStr) "%P", *message);
    SPrintf(winTitleCStr, (CStr) "%P", *winTitle);
    cb = (WORD)InvokeIndirectFunction(
              hMessageBox,
              messageCStr,
              winTitleCStr,
              0x1 );
out:
    if (messageCStr)
        DSDisposePtr(messageCStr);
    if (winTitleCStr)
        DSDisposePtr(winTitleCStr);
    if (hDLL)
        FreeLibrary(hDLL);
    return cinErr;
    }
```

The CIN first loads the library, and then gets the address of the DLL entry point. As described in the *Watcom C/386 User's Guide*, a Watcom DLL has only one entry point, `Win386LibEntry`. Calling `GetProcAddress` for a Watcom DLL requests the address of this entry point. For a DLL created using a compiler other than the Watcom C compiler, request the address of the function you want to call.

To prepare for the DLL call after getting the address, the example calls `GetIndirectFunctionHandle`. Use this function to specify the data types for the parameters you want to pass. The list is terminated with the `INDIR_ENDLIST` value. Because there is only one entry point with a Watcom DLL, pass an additional parameter (the `INDIR_WORD` parameter) that is the number of the routine you want to call in the DLL. With a DLL created using another compiler, you do not need to pass a function number, because `GetProcAddress` returns the address of the desired function.

This example uses `InvokeIndirectFunction` to call the desired DLL function, passing the number of the routine the example calls as the last parameter. With a DLL made by a compiler other than the Watcom C compiler, you don't need to pass the function number, because `GetProcAddress` returns the address of the desired function.

Notice at each stage of calling the DLL, the code checks for errors and returns an error code if it fails.

Notice also LabVIEW strings are different from C strings. C strings are terminated with a null character. LabVIEW strings are not null-terminated; instead, they begin with a four byte value indicating the length of the string. Because the DLL expects C strings, this example creates temporary buffers for the C strings using `DSNewPtr`, and then uses `SPrintf` to copy the LabVIEW string into the temporary buffers. You might consider modifying the DLL to accept LabVIEW strings instead, because that would require no temporary copies of the strings.

Compiling the CIN

Following is the LabVIEW makefile for this CIN. It assumes the `.c` file is named `msgbox.c`, the makefile is named `msgbox.lvm`, and the three pathnames for the directives `codeDir`, `cinToolsDir`, and `wcDir` are set correctly.

```
name=msgbox
type=CIN
codeDir=c:\labview\examples\cins\dll
cinToolsDir=c:\labview\cintools
wcDir=c:\wc
!include $(cinToolsDir)\generic.mak
```

The following command line prompt compiles the CIN.

```
c:> wmake /f msgbox.lvm
```

Optimization

To optimize the performance of this CIN call `LoadLibrary` during the `CINLoad` routine, and call `FreeLibrary` during the `CINUnload` routine. This keeps the overhead of loading and unloading the DLL from affecting your run-time performance. The following code shows the modifications you need to make to `CINRun`, `CINLoad`, and `CINUnload` to implement this optimization.

```
HANDLE hDLL = NULL;

CIN MgErr CINLoad(RsrcFile rf)
   {
   hDLL = LoadLibrary("msgbxdll.dll");
   return noErr;
   }

CIN MgErr CINRun(LStrHandle message,
   LStrHandle winTitle,
   int32 *err)
   {
```

```
FARPROC      addr = NULL;
HINDIR       hMessageBox;
int          cb;
char         *messageCStr = NULL,
             *winTitleCStr = NULL;
MgErr        cinErr = noErr;

*err=0;
if (hDLL < HINSTANCE_ERROR) {
   *err = 1;/* LoadLibrary failed */
   goto out;
   }

addr = GetProcAddress(hDLL,"Win386LibEntry");
if (!addr) {
   *err = 2;/* GetProcAddress failed */
   goto out;
   }

hMessageBox = GetIndirectFunctionHandle(
          addr,
          INDIR_PTR,
          INDIR_PTR,
          INDIR_WORD,
          INDIR_ENDLIST );

if (!hMessageBox) {
   /* GetIndirectFunctionHandle failed */
   *err = 3;
   goto out;
   }

if (!(messageCStr =
   DSNewPtr(LStrLen(*message)+1))) {
   /* mem errs are serious-stop execution */
   cinErr=mFullErr;
   goto out;
   }

if (!(winTitleCStr =
   DSNewPtr(LStrLen(*winTitle)+1))) {
   /* mem errs are serious-stop execution */
   cinErr=mFullErr;
   goto out;
   }

SPrintf(messageCStr, (CStr) "%P", *message);
SPrintf(winTitleCStr, (CStr) "%P", *winTitle);
```

```
    cb = (WORD)InvokeIndirectFunction(
              hMessageBox,
              messageCStr,
              winTitleCStr,
              0x1 );

out:
    if (messageCStr)
        DSDisposePtr(messageCStr);
    if (winTitleCStr)
        DSDisposePtr(winTitleCStr);

    return cinErr;
    }

CIN MgErr CINUnload(void)
    {
    if (hDLL)
        FreeLibrary(hDLL);

    return noErr;
    }
```

4

External Subroutines

This chapter describes how to create and call shared external subroutines from other external code modules.

Introduction

An external subroutine (or *shared* external subroutine) is a function you can call from multiple external code modules. By placing common code in an external subroutine, you can avoid duplicating the code in each external code module. You can also use external subroutines to store information that must be accessible to multiple external code modules.

External subroutines are different from CINs in that LabVIEW diagrams do not call them directly. Instead, an external subroutine is a function CINs and other external subroutines call. You store external subroutines in separate files, not in VIs.

When you load a VI containing a CIN, LabVIEW determines whether the CIN references external subroutines. If it does, LabVIEW loads the external subroutines into memory and modifies the calling code so it can call the subroutine. LabVIEW modifies any additional subroutines referencing the same external subroutine to reference the code already in memory. When you remove the last code referencing the external subroutine from memory (when you close the VI containing the CIN), LabVIEW also unloads the external subroutine.

Placing code in external subroutines is helpful for several reasons.

- A single subroutine is easier to maintain, because you need update only a single file to affect all calls on the subroutine.
- A single subroutine can also reduce memory requirements, because only a single instance of the code is in memory, regardless of the number of calls to the subroutine.
- An external subroutine can maintain information used by multiple external code modules. The first time the external subroutine is called, it can store data in a variable global to the external subroutine. Other external code modules can call the same external subroutine to retrieve the common data.

You store external subroutines as files, so you have to give each one a unique name. When LabVIEW searches for a subroutine file, it loads the first file it finds with the correct name.

☞ **Note** ***External subroutines are not supported on the Power Macintosh. The Macintosh OS on the Power Macintosh uses shared libraries, which provide a much cleaner mechanism for sharing code. If you need to share code among multiple CINs on the Power Macintosh, consult your development environment documentation to learn how to build a shared library.***

Although external subroutines are supported on Solaris 2, HP-UX, and Concurrent PowerMAX, it is suggested you use shared libraries instead.

Shared library mechanisms compatible with LabVIEW are available on all platforms. Under Microsoft Windows 3.1, Windows 95, and Windows NT, they are referred to as DLLs (dynamic link libraries). Under UNIX they are referred to as shared libraries or dynamic libraries.

Creating Shared External Subroutines

Normally, when you use a compiler to create a program, the compiler includes the code for all subroutines in a single file called the *executable*. External subroutines differ from standard subroutines in that you do not compile the code for the external subroutine with the code for the calling subroutine. Instead, your makefile, and consequently the code, indicate the calling code references an external subroutine. LabVIEW loads external subroutines based on this information and links the calling code in memory, so the calling code points correctly to the external subroutine.

You need to compile the calling code, even though its subroutines are not all present. LabVIEW must be able to determine that your code calls an external subroutine, find the subroutine, and load it into memory. When the subroutine is loaded, LabVIEW must be able to modify the memory image of the calling code so it correctly references the memory location of the external code. Finally, LabVIEW may need to create and initialize memory space the external subroutine uses for global data. The following sections describe how to make this work.

External Subroutines

LabVIEW calls CINs, but only your code calls external subroutines. Instead of creating seven routines (`CINRun`, `CINSave`, and so on), you create only one entry point (`LVSBMain`) for an external subroutine. When another external code module calls this external subroutine, the `LVSBMain` subroutine executes.

`LVSBMain` is similar to `CINRun`. You can have an arbitrary number of parameters, and each parameter can be of arbitrary data type. Also, because only your code calls the subroutine, you can declare any return data type, and you do not need to place the word `CIN` in front of the function prototype. You must ensure the parameters and return value are consistent between the calling and called code.

You compile an external subroutine almost the same way you compile a CIN. Because multiple external code modules can call the same external subroutine, LabVIEW does not load the code into a specific VI. Instead, LabVIEW loads the code from the file created by the makefile when the code is needed.

Macintosh

(THINK C Compiler and CodeWarrior 68K Compiler) To make a subroutine using the THINK or CodeWarrior 68K C Compiler, build the code resource (the `.tmp` file) as discussed in the *Steps for Creating a CIN* section of Chapter 1, *CIN Overview*, but replace the `CINLib` library with the appropriate LVSBLib library and select the **subroutine** option when running `lvsbutil.app`.

(MPW Compiler) The only difference between the makefiles of subroutines and of CINs is that for a subroutine you specify a type of `LVSB` in your `.lvm` file instead of `CIN`. See the *Steps for Creating a CIN* section of Chapter 1, *CIN Overview*, for a discussion of the makefile contents.

Microsoft Windows 3.1, Windows 95, and Windows NT

The only difference between the makefiles of subroutines and of CINs is that for a subroutine you specify a type of `LVSB` in your `.lvm` file instead of `CIN`. See the *Steps for Creating a CIN* section of Chapter 1, *CIN Overview*, for a discussion of the makefile contents.

Solaris 1.*x*, Solaris 2.*x*, HP-UX, and Concurrent PowerMAX

(Unbundled Sun C Compiler, HP-UX C/ANSI C Compiler, and Concurrent C Compiler) The `lvmkmf` command for a CIN calling an external subroutine is the same as described in the *Steps for Creating a CIN* section of Chapter 1, *CIN Overview*, except you use the `-t` option with the type `LVSB` to indicate you are creating a LabVIEW subroutine instead of a CIN.

For example, if you want to create an external subroutine called `find`, you could use the following command:

```
lvmkmf -t LVSB find
```

This command creates a makefile you could use to create the external subroutine.

Calling Code

You call external subroutines the same way you call standard C subroutines. LabVIEW modifies the code at load time to ensure the calling code passes control to the subroutine correctly.

When you call the external subroutine, do not use the function name `LVSBMain` to call the function. Instead, use the name you gave the external subroutine. If you created an external subroutine called `fact.lsb`, which in turn contained an `LVSBMain()` subroutine, for example, you should call the function as though it were named `fact()`. The argument list and return type should be the same as the argument and return type for the `LVSBMain()` subroutine.

You should also create a prototype for the function. This prototype should have the keyword `extern` so the compiler will compile the CIN, even though the subroutine is not present.

When you create the makefile for the CIN, you identify the names of the external subroutines the CIN calls. The LabVIEW makefile embeds information in your code LabVIEW uses to determine your code calls external subroutines. When you load external code referencing external subroutines into a VI, LabVIEW searches for the subroutine files. If it finds the subroutines, LabVIEW performs the appropriate linking. If a file is not found, LabVIEW displays a dialog box prompting you to find it. If you dismiss the dialog box without selecting the file, the VI loads into memory with a broken run arrow, indicating the VI is not executable.

One way to ensure LabVIEW can find external subroutines is to place them in the directories you defined in the search path section of the LabVIEW defaults file. See the *Configuring LabVIEW* section of Chapter 8, *Customizing Your LabVIEW Environment*, of your *LabVIEW User Manual* for more information on setting path preferences.

Macintosh

(THINK C Compiler) The THINK C project must have an extra file named `glue.c` specifying each external subroutine. Each reference to the external subroutine should have an entry as follows in the `glue.c` file:

```
long gLVSB<external subroutine name> = 'LVSB';
void <external subroutine name>(void);
void <external subroutine name>(void) {
    asm {
        move.l gLVSB<external subroutine name>, a0
        jmp          (a0)
}
    }
```

(CodeWarrior 68K Compiler) The CodeWarrior project must have an extra file called `glue.c`, which specifies each external subroutine. Each reference to the external subroutine should have an entry as follows in the `glue.c` file:

```
long gLVSB<external subroutine name> = 'LVSB';
void <external subroutine name>(void);
asm void <external subroutine name>(void) {
       move.l gLVSB<external subroutine name>, a0
       jmp          (a0)
       }
```

(MPW Compiler) The makefile for a calling CIN is the same as described in the *Steps for Creating a CIN* section of Chapter 1, *CIN Overview*, except you use the optional `subrNames` directive to identify the subroutines the CIN references. Specifically, if your code calls two external subroutines, `A` and `B`, you need to have the following line in the makefile code:

```
subrNames = A B
```

Microsoft Windows 3.1, Windows 95, and Windows NT

The makefile for a calling CIN is the same as described in the *Steps for Creating a CIN* section of Chapter 1, *CIN Overview*, except you use the optional `subrNames` directive to identify the subroutines the CIN references. Specifically, if your code calls two external subroutines, `A` and `B`, you need to have the following line in the code makefile, prior to the `!include` statement.

```
subrNames = A B
```

If you are using the Visual C IDE, follow the steps described in *Steps for Creating a CIN* section of Chapter 1, *CIN Overview*, with the exception of adding `lvsb.obj` instead of `cin.obj` to your project.

Solaris 1.*x*, Solaris 2.*x*, HP-UX, and Concurrent PowerMAX

(Unbundled Sun C Compiler, HP-UX C/ANSI C Compiler, and Concurrent C Compiler) The `lvmkmf` command for a calling CIN is the same as described in the *Steps for Creating a CIN* section of Chapter 1, *CIN Overview*, except you use the optional `-ext` option with the name of a file listing the names of the subroutines called by the CIN, one name per line. The makefile `lvmkmf` creates uses this file to append linkage information to the CIN object file.

For example, if your code calls two external subroutines, `A` and `B`, you create a new text file with the name `A` on the first line and `B` on the second. If the list of subroutines is in a file called `subrs`, and you want to call the calling CIN lookup, you can use the following command to create a makefile.

```
lvmkmf -ext subrs lookup
```

This command creates a makefile you can use to create the CIN.

External Subroutine Example

The following example illustrates the process of building an external subroutine that sums the elements of an array. This external subroutine can be used by a CIN that computes the mean and also by a CIN that computes the definite integral.

As described in the *External Subroutines* section of this chapter, you must write a function called `LVSBMain()`. When you call the external subroutine from your CIN or another external subroutine, LabVIEW passes control to the `LVSBMain()` function. When you call the external subroutine, the arguments to it and to its return type should be the same as in the definition of `LVSBMain()`.

The following is the C code for this external subroutine. Name it `sum.c`.

```
/*
 * sum.c
 */
#include "extcode.h"
float64 LVSBMain(float64 *x, int32 n);
float64 LVSBMain(float64 *x, int32 n)
    {
    int32 i;
    float64 sum;

    sum = 0.0;
    for (i=0; i<n; i++)
        sum += *x++;

    return sum;
    }
```

Compiling the External Subroutine

The procedure you use in compiling the external subroutine depends upon the platform and programming environment you are using.

Macintosh

(THINK C Compiler and CodeWarrior 68K Compiler) To make a subroutine using the THINK or CodeWarrior 68K C Compiler, create a project named `sum` or `sum.µ`, respectively, and add `sum.c` and `LVSBLib` to the project. Do not include the `CINLib` file in your project. Set the options in the **Options...** and **Set Project Type** dialog boxes as described in the *Steps for Creating a CIN* section of Chapter 1, *CIN Overview*. After you create `sum.tmp`, run `lvsbutil.app` and select the **Subroutine** option.

(MPW Compiler) As described in the *External Subroutines* section of this chapter, you compile an external subroutine the same way you compile a CIN. The first step is to create a makefile specification. Following are the contents of the makefile specification for this example. Notice all `Dir` commands must end with a colon (`:`). Name the file `sum.lvm`.

name = *name*	sum
type = *type*	LVSB
`codeDir = codeDir`:	Complete pathname to the folder containing the `.c` file.
`cinToolsDir = cinToolsDir`:	Complete or partial pathname to the LabVIEW `cintools` folder.
`inclDir = inclDir`:	(optional) Complete or partial pathname to a folder containing additional `.h` files.

Create the subroutine using the following command.

```
Directory <full pathname to CIN directory>
cinmake sum
```

Microsoft Windows 3.1

(Watcom C Compiler) As described in the *External Subroutines* section of this chapter, you compile an external subroutine the same way you compile a CIN. The first step is to create a makefile specification. Following are the contents of the makefile specification for this example. Notice all `Dir` commands must end *without* a backslash(\). Name the file `sum.lvm`.

`name = name`	`sum`
`type = type`	LVSB
`codeDir = codeDir`	Complete pathname to the directory containing the `.c` file.
cinToolsDir = *cinToolsDir*	Complete or partial pathname to the LabVIEW cintools directory.

`inclDir = inclDir`	(optional) Complete or partial pathname to a directory containing any additional `.h` files.
`wcDir = wcDir`	Complete pathname to the directory containing the Watcom C compiler.

```
!include $(cinToolsDir)\generic.mak
```

Create the subroutine using the following command.

```
wmake /f sum.lvm
```

Microsoft Windows 95 and Windows NT

As described in the *External Subroutines* section of this chapter, you compile an external subroutine the same way you compile a CIN. The first step is to create a makefile specification. Following are the contents of the makefile specification for this example. Name the file `sum.lvm`.

`name = name`	`sum`
`type = type`	`LVSB`

```
!include $(CINTOOLSDIR)\ntlvsb.mak
```

Create the subroutine using the following command.

```
nmake /f sum.lvm
```

Solaris 1.*x*, Solaris 2.*x*, HP-UX, and Concurrent PowerMAX

(Unbundled Sun C Compiler, HP-UX C/ANSI C Compiler, and Concurrent C Compiler) As described in the *External Subroutines* section of this chapter, you compile an external subroutine the same way you compile a CIN. The first step is to create the makefile for the subroutine using the shell script `lvmkmf`. You can then use the standard **make** command to make the subroutine code. For this example, enter the following command.

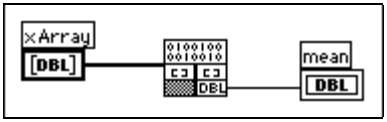
```
lvmkmf -t LVSB sum
```

This creates a file called `Makefile`. After executing `lvmkmf`, enter `make`, which uses the makefile to create a file called `sum.lsb`. CINs and other external subroutines can call this `sum.lsb` file.

Calling Code Example

The following example shows how to call an external subroutine. In this example, a CIN uses the external subroutine to calculate the mean of an array.

The diagram for the VI is shown in the following illustration. To avoid confusion, create the calling source code and makefiles in a directory separate from the external subroutine. Save the VI as `calcmean.vi`.



Save the `.c` file for the CIN as `calcmean.c`. The following is a listing of `calcmean.c`, with its `CINRun` routine filled in and the prototype for the `sum` external routine added.

```
/*
 * CIN source file
 */

#include "extcode.h"

/*
 * typedefs
 */

typedef struct {
   int32 dimSize;
   float64 arg1[1];
   } TD1;
typedef TD1 **TD1Hdl;

extern float64 sum(float64 *x, int32 n);

CIN MgErr CINRun(TD1Hdl xArray, float64 *mean);

CIN MgErr CINRun(TD1Hdl xArray, float64 *mean)
   {
   float64 *x, total;
   int32 n;

   x = (*xArray)->arg1;
   n = (*xArray)->dimSize;
   total = sum(x, n);
   *mean = total/(float64)n;
   return noErr;
   }
```

CINRun calculates the mean using the external subroutine sum to calculate the sum of the array. The external subroutine is declared with the keyword extern so the code compiles even though the subroutine is not present.

Compiling the Calling Code

The procedure you use for compiling the calling code depends upon which platform and programming environment you are using.

Macintosh

(THINK C Compiler) The THINK C project must have an extra file called glue.c which specifies each external subroutine. The reference to the external subroutine sum should have an entry as follows in the glue.c file:

```
long gLVSBsum = 'LVSB';
void sum(void);
void sum(void) {
    asm {
        move.l gLVSBsum, a0
        jmp(a0)
        }
    }
```

(CodeWarrior 68K Compiler) The CodeWarrior project must have an extra file called glue.c, which specifies each external subroutine. Each reference to the external subroutine sum should have an entry as follows in the glue.c file:

```
long gLVSBsum = 'LVSB';
void sum(void);
asm void sum(void){
        move.l gLVSBsum, a0
        jmp          (a0)
        }
```

(MPW Compiler) As described in the *Calling Code Example* section of this chapter, when you compile a CIN referencing an external subroutine, you use the same makefile as described in the *Steps for Creating a CIN* section of the Chapter 1, *CIN Overview*, with the addition of a directive identifying the subroutines this CIN uses. Following are the contents of the makefile specification for this example. Notice the Dir command must end in a colon (:). Name the makefile calcmean.lvm.

`name = name`	`calcmean`
`type = type`	`CIN`
`codeDir = codeDir`:	Complete pathname to the folder containing the `.c` file.
`cinToolsDir = cinToolsDir`:	Complete or partial pathname to the LabVIEW cintools folder.
`inclDir = inclDir`:	(optional) Complete or partial pathname to a folder containing additional `.h` files.
subrNames = *subrNames*	sum

Create the CIN using the following command:

```
Directory <full pathname to CIN directory>
cinmake sum
```

Microsoft Windows 3.1

(Watcom C Compiler) As described in the *Calling Code* section of this chapter, when you compile a CIN referencing an external subroutine, you use the same makefile as described in the *Steps for Creating a CIN* section of the Chapter 1, *CIN Overview*, with the addition of a directive identifying the subroutines this CIN uses. Following are the contents of the makefile specification for this example. Notice the `Dir` command must end *without* a backslash (\). Name the makefile `calcmean.lvm`.

`name = name`	`calcmean`
`type = type`	`CIN`
`codeDir = codeDir`	Complete pathname to the directory containing the `.c` file.
`cinToolsDir = cinToolsDir`	Complete or partial pathname to the LabVIEW `cintools` directory.
`inclDir = inclDir`	(optional) Complete or partial pathname to a directory containing additional `.h` files.

```
wcDir = wcDir                Complete pathname to the directory
                             containing the Watcom C compiler.

subrNames = subrNames        sum
!include $(cinToolsDir)\generic.mak
```

Create the CIN using the following command:

```
wmake /f calcmean.lvm
```

Microsoft Windows 95 and Windows NT

(Microsoft Visual C Command Line) As described in the *Calling Code* section of this chapter, when you compile a CIN referencing an external subroutine, you use the same makefile as described in the *Steps for Creating a CIN* section of the Chapter 1, *CIN Overview*, with the addition of a directive identifying the subroutines this CIN uses. Following are the contents of the makefile specification for this example. Name the makefile `calcmean.lvm`.

```
name = name                  calcmean

type = type                  CIN

subrNames = subrNames        sum
!include $(CINTOOLSDIR)\ntlvsb.mak
```

Create the CIN using the following command:

```
nmake /f calcmean.lvm
```

(Microsoft Visual C IDE) Building CINs that use external subroutines is not supported using Microsoft Visual C IDE. A possible alternative would be to use a DLL instead of an external subroutine.

Solaris 1.*x*, Solaris 2.*x*, HP-UX, and Concurrent PowerMAX

(Unbundled Sun C Compiler, HP-UX C/ANSI C Compiler, and Concurrent C Compiler) As described in the *Calling Code* section of this chapter, when you compile a CIN referencing an external subroutine, you use the `lvmkmf` script with an addition directive identifying a file with the names of all subroutines the CIN calls.

For this example, create a text file with the name `meansubs`. It should contain a single line with the word `sum`.

You then create the makefile for this CIN using the following command:

```
lvmkmf -ext meansubs calcmean
```

This creates a file called `Makefile`. After executing `lvmkmf`, enter `make`, which uses the makefile to create a file called `calcmean.lsb`. You can load the `calcmean.lsb` file into the CIN.

5

Manager Overview

This chapter gives an overview of the function libraries, called *managers*, which you can use in external code modules. These include the memory manager, the file manager, and the support manager. The chapter also introduces many of the basic constants, data types, and globals contained in the LabVIEW libraries.

☞ **Note** ***For descriptions of specific manager functions, see the*** *CIN Function Overview* ***section of the LabVIEW*** *Online Reference****, available by selecting*** **Help»Online Reference.**

Introduction

External code modules have a large set of functions you can use to perform simple and complex operations. These functions, organized into libraries called managers, range from low-level byte manipulation to routines for sorting data and managing memory. All manager routines described in this chapter are platform-independent. If you use these routines, you can create external code modules that will work on all platforms LabVIEW supports.

A fundamental component of platform independence are data types that do not depend on the peculiarities of various compilers. The C language, for example, does not define the size of an integer. Without an explicit definition of the size of each data type, it is almost impossible to create code that works identically across multiple compilers.

LabVIEW managers use data types that explicitly indicate their size. For example, if a routine requires a 4-byte integer as a parameter, you define the parameter as an `int32`. The managers define data types in terms of the fundamental data types for each compiler. Thus, on one compiler, the managers might define an `int32` as an `int`, while on another compiler, the managers might define an `int32` as a `long int`. When writing external code modules, use the manager data types instead of the host computer data types, because your code will be more portable and have fewer errors.

Most applications need routines for allocating and deallocating memory on request. You can use the *memory manager* to dynamically allocate, manipulate, and release memory. The LabVIEW memory manager

supports dynamic allocation of both non-relocatable and relocatable blocks, using pointers and handles. For more information, see the *Memory Manager* section of the LabVIEW *Online Reference* for more information.

Applications that manipulate files can use the functions in the *file manager.* This set of routines supports basic file operations such as creating, opening, and closing files, writing data to files, and reading data from files. In addition, file manager routines allow you to create directories, determine characteristics of files and directories, and copy files. File manager routines use a LabVIEW data type for file pathnames (`Path`s) that provides a platform-independent way of specifying a file or directory path. You can translate a `Path` to and from a host platform's conventional format for describing a file pathname. See the *File Manager* section of the LabVIEW *Online Reference* for more information.

The *support manager* contains a collection of generally useful functions, such as functions for bit or byte manipulation of data, string manipulation, mathematical operations, sorting, searching, and determining the current time and date. See the *Support Manager* section of the LabVIEW *Online Reference* for more information.

Basic Data Types

There are five basic data types: scalar, the char data type, dynamic, memory-related, and constants.

Scalar Data Types

The two kinds of scalar data types are Booleans and numerics, described below.

Booleans

External code modules work with two kinds of Booleans—those existing in LabVIEW block diagrams and those passing to and from manager routines. The manager routines use a conventional form of Boolean, where 0 is FALSE and 1 is TRUE. This form of Boolean is called a `Bool32`, and it is stored as a 32-bit value.

LabVIEW block diagrams store Boolean scalars as 8-bit values. The value is 1 if the Boolean is TRUE, and 0 if the Boolean is FALSE. This form of Boolean is called an `LVBoolean`.

The two forms of Booleans are summarized in the following table.

Name	Description
`Bool32`	32-bit integer, 1 if TRUE, 0 if FALSE
`LVBoolean`	8-bit integer, 1 if TRUE, 0 if FALSE

Numerics

The managers support 8-, 16-, and 32-bit signed and unsigned integers. For floating-point numbers, LabVIEW supports the single (32-bit), double (64-bit), and extended floating-point (at least 80-bit) data types. LabVIEW supports complex numbers containing two floating-point numbers, with different complex numeric types for each of the floating-point data types. The following lists show the basic LabVIEW data types for numbers.

- Signed Integers
  - `int8` 8-bit integer
  - `int16` 16-bit integer
  - `int32` 32-bit integer
- Unsigned Integers
  - `uInt8` 8-bit unsigned integer
  - `uInt16` 16-bit unsigned integer
  - `uInt32` 32-bit unsigned integer
- Floating-Point Numbers
  - `float32` 32-bit floating-point number
  - `float64` 64-bit floating-point number
  - `floatExt` extended-precision floating-point number

In Windows, extended-precision numbers are stored as an 80-bit structure with two `int32` components, `mhi` and `mlo`, and an `int16` component, `e`. On the Sun, extended-precision numbers are stored as 128-bit floating-point numbers. On the 68K Macintosh, extended-precision numbers are stored in the 96-bit MC68881 format. On the Power Macintosh, extended-precision numbers are stored in the 128-bit double-double format. On HP and Concurrent, extended precision numbers are the same as float64.

Complex Numbers

The complex data types are structures with two floating-point components, `re` and `im`. As with floating-point numbers, complex numbers can have 32-bit, 64-bit, and extended-precision components. The following segments of code give the type definitions for each of these complex data types.

```
typedef struct {
   float32 re, im;
   } cmplx64;
typedef struct {
   float64 re, im;
   } cmplx128;
typedef struct {
   floatExt re, im;
   } cmplxExt;
```

char Data Type

The `char` data type is defined by C to be a signed byte value. LabVIEW defines an unsigned `char` data type, with the following type definition.

```
typedef uInt8 uChar;
```

Dynamic Data Types

LabVIEW defines a number of data types you must allocate and deallocate dynamically. *Arrays*, *strings*, and *paths* have data types you must allocate using memory manager and file manager routines.

Arrays

LabVIEW supports arrays of any of the basic data types described in the *Scalar Data Types* section of this chapter. You can construct more complicated data types using clusters, which can in turn contain scalars, arrays, and other clusters.

The first four bytes of a LabVIEW array indicate the number of elements in the array. The elements of the array follow the length field. Chapter 2, *CIN Parameter Passing*, gives examples of how to manipulate arrays.

Strings

LabVIEW supports C-style strings and Pascal-style strings, a special string data type you use for string parameters to external code modules called `LStr`, and lists of strings. The support manager contains routines for manipulating strings and converting them among the different types of strings.

C-Style Strings (CStr)

A C string (`CStr`) is a series of zero or more unsigned characters, terminated by a zero. C strings have no effective length limit. Most manager routines use C strings, unless you specify otherwise. The following code segment is the type definition for a C-style string.

```
typedef uChar *CStr;
```

Pascal-Style Strings (PStr)

A Pascal string (`PStr`) is a series of unsigned characters. The value of the first character indicates the length of the string. This gives a range of 0 to 255 characters. The following code segment is the type definition for a Pascal-style string.

```
typedef uChar       Str255[256], Str31[32],
                    *StringPtr,
                    **StringHandle;
typedef uChar       *PStr;
```

LabVIEW Strings (LStr)

The first four bytes of a LabVIEW string (`LStr`) indicate the length of the string, and the specified number of characters follow. This is the string data type used by LabVIEW block diagrams. The following code segment is the type definition for an `LStr` string.

```
typedef struct {
   int32 cnt;
   /* number of bytes that follow */
   uChar str[1];
   /* cnt bytes */
   } LStr, *LStrPtr, **LStrHandle;
```

Concatenated Pascal String (CPStr)

Many algorithms require manipulation of lists of strings. Arrays of strings are usually the most convenient representation for lists. This representation can place a burden on the memory manager, however, because of the large number of dynamic objects that must be managed. To make working with lists more efficient, LabVIEW supports the concatenated Pascal string (`CPStr`) data type that is a list of Pascal-style strings concatenated into a single block of memory. You can use support manager routines to create and manipulate lists using this data structure.

This data type is defined as follows.

```
typedef struct {
   int32 cnt;
   /* number of pascal strings that follow */
   uChar str[1];
   /* cnt concatenated pascal strings */
   } CPStr, *CPStrPtr, **CPStrHandle;
```

Paths (Path)

A path (short for pathname) specifies the location of a file or directory in a computer's file system. There is a separate LabVIEW data type for a path (represented as `Path`), which the file manager defines in a platform-independent manner. The actual data type for a path is private to the file manager and subject to change. You create and manipulate `Path`s using file manager routines.

Memory-Related Types

LabVIEW uses pointers and handles to reference dynamically allocated memory. These data types are described in detail in the *CIN Function Overview* section of the LabVIEW *Online Reference* and have the following type definitions.

```
typedef uChar *UPtr;
typedef uChar **UHandle;
```

Constants

The managers define the following constant for use with external code modules.

```
NULL 0(uInt32)
```

The following constants define the possible values of the `Bool32` data type.

```
FALSE 0 (int32)
TRUE 1 (int32)
```

The following constants define the possible values of the `LVBoolean` data type.

```
LVFALSE 0 (uInt8)
LVTRUE 1 (uInt8)
```

Memory Manager

This section describes the memory manager, a set of platform-independent routines for allocating, manipulating, and deallocating memory from external code modules.

Read this section if you need to perform dynamic memory allocation or manipulation from external code modules. If your external code operates on data types other than scalars, you need to understand how LabVIEW manages memory and know the utilities that manipulate data.

☞ **Note** ***For descriptions of specific memory manager functions, see the*** *Memory Manager* ***section of the LabVIEW*** *Online Reference****, available by selecting*** **Help»Online Reference.**

Memory Allocation

Applications use two types of memory allocation: static and dynamic.

Static Memory Allocation

With static allocation, the compiler determines memory requirements when you create a program. When you launch the program, LabVIEW creates memory for the known global memory requirements of the application. This memory remains allocated while the program runs. This form of memory management is very simple to work with because the compiler handles all the details.

Static memory allocation cannot address the memory management requirements of most real-world applications, however, because you cannot determine most memory requirements until run-time. Also, statically declared memory may result in larger memory requirements, because the memory is allocated for the life of the program.

Dynamic Memory Allocation: Pointers and Handles

With dynamic memory allocation, you reserve memory when you need it, and free memory when you are no longer using it. Dynamic allocation requires more work on your part than static memory allocation, because you have to determine memory requirements and allocate and deallocate memory as necessary.

The LabVIEW memory manager supports two kinds of dynamic memory allocation. The more conventional method uses pointers to allocate memory. With pointers, you request a block of memory of a given size, and the routine returns the address of the block to your CIN. When you no longer need the block of memory, you call a routine to free the block. You can use the block of memory to store data, and you reference that data using the address the manager routine returned when you created the pointer. You can make copies of the pointer and use them in multiple places in your program to refer to the same data.

Pointers in the LabVIEW memory manager are nonrelocatable, which means the manager never moves the memory block to which a pointer refers while that memory is allocated for a pointer. This avoids problems that occur when you need to change the amount of memory allocated to a pointer because other references would be out of date. If you need more memory, there might not be sufficient memory to expand the pointer's memory space without moving the memory block to a new location. This causes problems if an application had multiple references to the pointer, because each pointer refers to the old memory address of the data. Using invalid pointers can cause severe problems.

A second form of memory allocation uses handles to address this problem. As with pointers, when you allocate memory using handles, you request a block of memory of a given size. The memory manager allocates the memory and adds the address of the memory block to a list of *master pointers*. The memory manager returns a handle that is a pointer to the master pointer. If you reallocate a handle and it moves to another address, the memory manager updates the master pointer to refer to the new address. As long as you look up the correct address using the handle, you access the correct data.

You use handles to perform most memory allocation in LabVIEW. Pointers are available, however, because in some cases they are more convenient and simpler to use.

Memory Zones

LabVIEW's memory manager interface has the ability to distinguish between two distinct sections, called zones. LabVIEW uses the data space (DS) zone only to hold VI execution data. LabVIEW uses the application zone (AZ) to hold all other data. Most memory manager functions have two corresponding routines, one for each of the two zones. Routines that operate on the data space zone begin with DS and routines for the application zone begin with AZ.

Currently, the two zones are actually one zone, but this may change in future releases of LabVIEW; therefore, a CIN programmer should write programs as if the two zones actually exist.

External code modules work almost exclusively with data created in the DS zone, although exceptions exist. In most cases, you use the DS routines when you need to work with dynamically allocated memory.

All data passed to or from a CIN is allocated in the DS zone except for `Path`s, which use AZ handles. You should only use file manager functions (not the AZ memory manager routines) to manipulate `Path`s. Thus, your CINs should use the DS memory routines when working with parameters passed from the block diagram. The only exceptions to this rule are handles created using the `SizeHandle` function, which allocates handles in the application zone. If you pass one of these handles to a CIN, your CIN should use AZ routines to work with the handle.

Using Pointers and Handles

Most memory manager functions have a DS routine and an AZ routine. In the following discussion, *`XXFunctionName`* refers to a function in a general context. In these situations, *`XX`* can be either *`DS`* or *`AZ`*. When a difference exists between the two zones, the specific function name is given.

You create a handle using `XXNewHandle`, with which you specify the size of the memory block. You create a pointer using `XXNewPtr`. `XXNewHandleClr` and `XXNewPClr` are variations that create the memory block and set it to all zeros.

When you are finished with the handle or pointer, release it using `XXDisposeHandle` or `XXDisposePtr`.

If you need to resize an existing handle, you can use the `XXSetHandleSize` routine. `XXGetHandleSize` determines the size of an existing handle. Because pointers are not relocatable, you cannot resize them.

A handle is a pointer to a pointer. In other words, a handle is the address of an address. The second pointer, or address, is a master pointer, which means it is maintained by the memory manager. Languages that support pointers provide operators for accessing data by its address. With a handle, you use this operator twice; once to get to the master pointer, and a second time to get to the actual data. A simple example of how to work with pointers and handles in C is shown in the following section.

While operating within a single call of a CIN node, an AZ handle will not move unless you specifically resize it. In this context there is no need to lock or unlock handles. If your CIN maintains an AZ handle across different calls of the same CIN (an asynchronous CIN), the AZ handle may be relocated between calls. In this case, `AZHLock` and `AZHUnlock` may be useful if you do not want the handle to relocate. A DS handle will never move unless you resize it.

Additional routines make it easy to copy and concatenate handles and pointers to other handles, check the validity of handles and pointers, and copy or move blocks of memory from one place to another.

Simple Example

The following example code shows how you work with a pointer to an `int32`.

```
int32 *myInt32P;

myInt32P = (int32 *)DSNewPtr(sizeof(int32));
*myInt32P = 5;
x = *myInt32P + 7;
...
DSDisposePtr(myInt32P);
```

The first line declares the variable `myInt32P` as a pointer to, or the address of, a signed 32-bit integer. This does not actually allocate memory for the `int32`; it creates memory for an address and associates the name `myInt32P` with that address. The `P` at the end of the variable name is a convention used in this example to indicate the variable is a pointer.

The second line creates a block of memory in the data space large enough to hold a single signed 32-bit integer and sets `myInt32P` to refer to this memory block.

The third line places the value 5 in the memory location to which `myInt32P` refers. The `*` operator refers to the value in the address location.

The fourth line sets `x` equal to the value at address `myInt32P` plus 7.

The last line frees the pointer.

The following code is the same example using handles instead of pointers.

```
int32 **myInt32H;

myInt32H =(int32**)DSNewHandle(sizeof(int32));
**myInt32H = 5;
x = **myInt32H + 7;
...
DSDisposeHandle(myInt32H);
```

The first line declares the variable `myInt32H` as a handle to an a signed 32-bit integer. Strictly speaking, this line declares `myInt32H` as a pointer to a pointer to an `int32`. As with the previous example, this declaration does not allocate memory for the `int32`; it creates memory for an address and associates the name `myInt32H` with that address. The `H` at the end of the variable name is a convention used in this example to indicate the variable is a handle.

The second line creates a block of memory in the data space large enough to hold a single `int32`. `DSNewHandle` places the address of the memory block as an entry in the master pointer list and returns the address of the master pointer entry. Finally, this line sets `myInt32H` to refer to the master pointer.

The third line places the value 5 in the memory location to which `myInt32H` refers. Because `myInt32H` is a handle, you use the `*` operator twice to get to the data.

The fourth line sets `x` equal to the value referenced by `myInt32H` plus 7.

The last line frees the handle.

This example shows only the simplest aspects of how to work with pointers and handles in C. Other examples throughout this manual show different aspects of using pointers and handles. Refer to a C manual for a list of other

operators you can use with pointers and a more detailed discussion of how to work with pointers.

Reference to the Memory Manager

See the *CIN Function Overview* section of the LabVIEW *Online Reference* for descriptions of the routines used for managing memory in external code segments of LabVIEW. For every function, if *XX* is AZ, the referenced handle, pointer, or block of memory is in the application zone. If *XX* is DS, the referenced handle, pointer, or block of memory is in the data space zone.

Memory Manager Data Structures

The memory manager defines generic handle and pointer data types as follows.

```
typedef uChar *Ptr;
typedef uChar **UHandle;
```

File Manager

The file manager supports routines for opening and creating files, reading data from and writing data to files, and closing files. In addition, with these routines you can manipulate the end-of-file mark of a file and position the current read or write mark to an arbitrary position in the file. With other file routines you can move, copy, and rename files, determine and set file characteristics and delete files.

☞ **Note** ***For descriptions of specific file manager functions, see the*** *File Manager* ***section of the LabVIEW*** *Online Reference****, available by selecting*** **Help»Online Reference.**

The file manager contains a number of routines for directories. With these routines you can create and delete directories. You can also determine and set directory characteristics and obtain a list of a directory's contents.

LabVIEW supports concurrent access to the same file, so you can have a file open for both reading and writing simultaneously. When you open a file, you can indicate whether you want the file to be read from and written to concurrently. You can also lock a range of the file, if you need to ensure a range is nonvolatile at a given time.

Finally, the file manager provides many routines for manipulating paths (short for pathnames) in a platform-independent manner. The file manager supports the creation of path descriptions, which are either relative to a

specific location or absolute (the full path). With file manager routines you can create and compare paths, determine characteristics of paths, and convert a path between platform-specific descriptions and the platform-independent form.

Identifying Files and Directories

When you perform operations on files and directories, you need to identify the target of the operation. The platforms LabVIEW supports use a hierarchical file system, meaning files are stored in directories, possibly nested several levels deep. These file systems support the connection of multiple discrete storage media, called volumes. For example, DOS-based systems support multiple drives connected to the system. For most of these file systems, you must include the volume name to completely specify the location of a file. On other systems, such as UNIX, you do not specify the volume name because the physical implementation of the file system is hidden from the user.

How you identify a target depends upon whether the target is an open or closed file. If a target is a closed file or a directory, you specify the target using the target's *path*. The path describes the volume containing the target, the directories between the top level and the target, and the target's name. If the target is an open file, you use a file descriptor to specify LabVIEW should perform an operation on the open file. The file descriptor is an identifier the file manager associates with the file when you open it. When you close the file, the file manager dissociates the file descriptor from the file.

Path Specifications

LabVIEW uses three different kinds of filepath specifications: conventional, empty, and LabVIEW specifications, described below.

Conventional Path Specifications

All platforms have a method for describing the paths for files and directories. These path specifications are similar, but they are usually incompatible from one platform to another. You usually specify a path as a series of names separated by separator characters. Typically, the first name is the top level of the hierarchical specification of the path, and the last name is the file or directory the path identifies.

There are two types of paths—*relative paths* and *absolute paths*. A relative path describes the location of a file or directory relative to

an arbitrary location in the file system. An absolute path describes the location of a file or directory starting from the top level of the file system.

A path does not necessarily go from the top of the hierarchy down to the target. You can often use a platform-specific tag in place of a name that indicates the path should go up a level from the current location.

For instance, on a UNIX system, you specify the path of a file or directory as a series of names separated by the slash (/) character. If the path is an absolute path, you begin the specification with a slash. You can indicate the path should move up a level using two periods in a row (..). Thus, the following path specifies a file `README` relative to the top level of the file system.

```
/usr/home/gregg/myapps/README
```

Two relative paths to the same file are as follows.

`gregg/myapps/README`	relative to `/usr/`home
`../myapps/README`	relative to a directory inside of the `gregg` directory

On the PC, you separate names in a path with a backslash (\ ) character. If the path is an absolute path, you begin the specification with a drive designation, followed by a colon (:), followed by the backslash. You can indicate the path should move up a level using two periods in a row (..). Thus, the following path specifies a file `README` relative to the top level of the file system, on a drive named `C`.

```
C:\HOME\GREGG\MYAPPS\README
```

Two relative paths to the same file are as follows.

`GREGG\MYAPPS\README`	relative to the `HOME` directory
`..\MYAPPS\README`	relative to a directory inside of the `GREGG` directory

On the Macintosh, you separate names in a path with the colon (:) character. If the path is an absolute path, you begin the specification with the name of the volume containing the file. If an absolute path consists of only one name (it specifies a volume), it must end with a colon. If the path is a relative path, it begins with a colon. This colon is optional for a relative path consisting of only one name. You can indicate the path should move up a level using two colons in a row (::). Thus, the following path specifies a file `README` relative to the top level of the file system, on a drive named `Hard Drive`.

```
Hard Drive:Home:Gregg:MyApps:README
```

Two relative paths to the same file are as follows.

`:Gregg:MyApps:README`	relative to the `Home` directory
`::MyApps:README`	relative to a directory inside of the `Gregg` directory

Empty Path Specifications

In LabVIEW you can define a path with no names, called an *empty path*. An empty path is either absolute or relative. The empty absolute path is the highest point you can specify in the file hierarchy. The empty relative path is a path relative to an arbitrary location in the file system to itself.

On a UNIX system, a slash (/) represents the empty absolute path. The slash specifies the root of the file hierarchy. A period (.) represents the empty relative path.

On the PC, you represent the empty absolute path as an empty string. It specifies the set of all volumes on the system. A period (.) represents the empty relative path.

On the Macintosh, the empty absolute path is represented as an empty string. It specifies the set of all volumes on the system. A colon (:) represents the empty relative path.

LabVIEW Path Specification

In LabVIEW, you specify a path using a special LabVIEW data type, represented as `Path`. The exact structure of the `Path` data type is private to the file manager. You create and manipulate the `Path` data type using file manager routines.

A `Path` is a dynamic data structure. Just as you use memory manager routines to allocate and deallocate handles and pointers, you use file manager routines to create and deallocate `Path`s. Just as with handles, declaring a `Path` variable does not actually create a `Path`. Before you can use the `Path` to manipulate a file, you must dynamically allocate the `Path` using file manager routines. When you are finished using the `Path` variable, you should release the `Path` using file manager routines.

In addition to providing routines for the creation and elimination of `Path`s, the file manager provides routines for comparing `Path`s, duplicating `Path`s, determining characteristics of `Path`s, and converting `Path`s to and from other formats, such as the platform-specific format for the system on which LabVIEW is running.

File Descriptors

When you open a file, LabVIEW returns a file descriptor associated with the file. A file descriptor is a data type LabVIEW uses to identify open files. All operations performed on an open file use the file descriptor to identify the file.

A file descriptor is valid only while the file is open. If you close the file, the file descriptor is no longer associated with the file. If you subsequently open the file, the new file descriptor will most likely be different from the file descriptor LabVIEW used previously.

File Refnums

In the file manager, LabVIEW accesses open files using file descriptors. On the front panel and block diagram, however, LabVIEW accesses open files through file refnums. A file refnum contains a file descriptor for use by the file manager, and additional information used by LabVIEW.

LabVIEW specifies file refnums using the `LVRefNum` data type, the exact structure of which is private to the file manager. If you want to pass references to open files into or out of a CIN, use the functions in the *File Refnums, Manipulating* topic of the *Online Reference* to convert file refnums to file descriptors, and to convert file descriptors to file refnums.

Support Manager

The support manager is a collection of constants, macros, basic data types, and functions that perform operations on strings and numbers. The support manager also has functions for determining the current time in a variety of formats.

☞ **Note** ***This section gives only a brief overview of the support manager. For descriptions of specific support manager functions, see the*** *Support Manager* ***section of the LabVIEW*** *Online Reference****, available by selecting*** **Help»Online Reference.**

The support manager's string functions contain much of the functionality of the string libraries supplied with standard C compilers, such as string concatenation and formatting. You can use variations of many of these functions with LabVIEW strings (4-byte length field followed by data, generally stored in a handle), Pascal strings (1-byte length field followed by data), and C strings (data terminated by a null character).

With the utility functions you can sort and search on arbitrary data types, using quicksort and binary search algorithms.

The support manager contains transcendental functions for many complex and extended floating-point operations.

Certain routines specify time as a data structure with the following form.

```
typedef struct {
   int32     sec;/* 0:59 */
   int32     min;/* 0:59 */
   int32     hour;/* 0:23 */
   int32     mday;/* day of the month, 1:31 */
   int32     mon;/* month of the year, 1:12 */
   int32     year;/* year, 1904:2040 */
   int32     wday;/* day of the week, 1:7 for Sun:Sat */
   int32     yday;/* day of year (julian date), 1:366 */
   int32     isdst;/* 1 if daylight savings time */
   } DateRec;
```

A

CIN Common Questions

This appendix answers some of the questions commonly asked by LabVIEW CIN users.

What compilers can be used to write CINs for LabVIEW?

(Microsoft Windows 3.1, Windows 95, and Windows NT) You can use the Watcom C/386 compiler, version 9.0 or later, to write CINs for LabVIEW for Windows 3.1. Other compilers for Windows 3.1 (including the Microsoft C compiler) do not generate the proper code for LabVIEW to operate as a 32-bit application. For a compiler to work with LabVIEW, it must generate a file in the `.REX` format (a 32-bit Phar Lap relocatable executable).

LabVIEW for Windows 95/NT supports additional compilers, including Microsoft Visual C++ and Symantec C.

(Macintosh) You can use the following compilers to compile your CIN source code: THINK C, version 7, for 68K (from Symantec Corporation of Cupertino, CA); Symantec C++, version 8, for PowerPC (from Symantec Corporation of Cupertino, CA); Metrowerks CodeWarrior for 68K (from Metrowerks Corporation of Austin, TX); Metrowerks CodeWarrior for Power Macintosh (from Metrowerks Corporation of Austin, TX); Macintosh Programmer's Workshop (MPW) for 68K and PowerPC (from Apple Computer, Inc. of Cupertino, CA).

(Sun) You can use the Sun ANSI-compatible compiler and the `gcc` compiler. The only officially supported compiler is the ANSI C compiler, also known as the unbundled C compiler or SPARCompiler C, which can be purchased from Sun. On Solaris 1.*x* machines, this compiler is commonly referred to as `acc` (ANSI C compiler); on Solaris 2.*x* machines, the compiler is called `cc`. The Gnu C compiler (`gcc`) is also ANSI-compatible and can be used to create CINs for LabVIEW for Sun. The only known limitation of the `gcc` compiler is it does not support extended-precision floating point numbers under Solaris 1.*x*. Source code for the `gcc` compiler is available for both Solaris 1.*x* and 2.*x* through anonymous ftp to `prep.ai.mit.edu`.

SPARCstations with Solaris 1.*x* come with the bundled C compiler (`cc`) that is not ANSI-compliant. Because the `cc` compiler requires substantial modification to the header files included with LabVIEW, National Instruments does not recommend using this compiler for CIN development.

Please note LabVIEW for Solaris 1.*x* does not accept object files created with the `-g` debugging flag turned on during compilation.

(HP and Concurrent) You can use the vendor-supplied compilers on these platforms.

My VI, which contains a CIN, crashes LabVIEW or gives a memory.c error.

In almost all cases this indicates an error in the C code of the CIN. Make sure the CIN code properly allocates or deallocates memory as necessary. See the section entitled *How LabVIEW Passes Variably Sized Data to CINs* in Chapter 2, *CIN Parameter Passing*, of this manual for further details and examples.

How do I debug my CIN?

You have several debugging options, depending upon the platform you use. The following list gives descriptions of some of the available methods.

- Use the `DbgPrintf` function, which creates a debugging window. Although the position and size of the window cannot be controlled, information can be posted to the window as the CIN code executes. Notice the window does not contain a scrollbar. `DbgPrintf` is described in the section entitled *Debugging External Code* in Chapter 1, *CIN Overview*, of this manual.
- If you are using a Macintosh and have `Macsbug`, you can use the `Debugger` and `DebugStr` statements to set breakpoints in the code.
- If you suspect your CIN is corrupting memory, use `DSHeapCheck(FALSE)` to test for integrity. Observe the heap integrity when you enter and again when you exit the CIN code to determine if your code is corrupting the heap.
- Use the File Manager functions to write your debugging information to a file. If you are observing this file while the CIN is running, do not forget to flush the file before the information gets to the disk.
- If the VI containing the CIN executes without crashing, but you do not have an external window and decide not to use `DbgPrintf`, then a) determine what information is pertinent to your problem, and b) return the information from one of the parameters of the CIN to the block diagram of the VI.

Is there any sort of `scanf` function in the LabVIEW manager routines?

No. National Instruments is investigating this functionality for a future version of LabVIEW. CINs with LabVIEW for Sun can call the standard `scanf` and related functions.

I can't seem to link to any of the globals mentioned in the *LabVIEW Code Interface Reference Manual*.

Examples of these globals include: `decimalPt`, `CrgRtnChar`, `LnFeedChar`, `EOLChar`, `TabChar`, `EmptyStrChar`, `SInfinity`, `SNegInfinity`, `DInfinity`, `DNegInfinity`, `EMaxW`, `EMaxL`, `EInfinity`, `ENegInfinity`, `DPi`, `DHalfPi`, `DThreeHalvesPi`, `DTwoPi`, `DRad2Deg`, `DTwo`, `DNan`, `EPi`, `EHalfPi`, `ETwoPi`, `EE`, `Eln10`, `Eln2`, `Elog10e`, `ELog2e`, `EHalf`, `EOne`, `ETwo`, `ETen`, `EZero`, `ERecipPi`, `ERecipE`, `EPlanck`, `EElemChg`, `ESpeedLt`, `EGravity`, `EAvgdro`, `ERydbrg`, `EMlrGas`, `ELnOfPi`, `ELogOfE`, `ELnOfTwo`, and `ENan`.

Although mentioned in the documentation, these globals are not exported for use in CINs. To get these values into your CIN code, pass them in as parameters to the CIN.

Can LabVIEW be used to call a DLL in Windows?

Yes. The Call Library Function calls a DLL function directly. The function is located in the **Advanced** palette of the **Functions** palette. Refer to Chapter 13 of the *LabVIEW Function and VI Reference Manual* for more details on this feature.

I get an error linking to a function when I build my CIN using the Windows platform.

The Watcom linker usually does not allow you to link with the Watcom library function modules when making a stand-alone module. If it does allow you to link, the code should work properly. Unfortunately, there is no clearly defined way to determine which functions will link and which will not; it is trial and error.

If this error occurs, the only way to work through the problem is to write a DLL that calls the library functions.

Why do I get garbage back from math functions such as `atan2`, `pow`, `ceil`, `floor`, `ldexp`, `frexp`, `modf`, and `fmod` when using MPW C?

Include `"Math.h"` at the top of your `.c` file.

Why can't I link to the math functions (sin, cos, and so on) when using THINK C?

Find the `math.c` and `error.c` functions that came with THINK C and include them in the project. Be sure to also include `"Math.h"` in the `.c` file. Then enable the 68881 options under THINK C preferences.

B

Customer Communication

For your convenience, this appendix contains forms to help you gather the information necessary to help us solve your technical problems and a form you can use to comment on the product documentation. When you contact us, we need the information on the Technical Support Form and the configuration form, if your manual contains one, about your system configuration to answer your questions as quickly as possible.

National Instruments has technical assistance through electronic, fax, and telephone systems to quickly provide the information you need. Our electronic services include a bulletin board service, an FTP site, a fax-on-demand system, and e-mail support. If you have a hardware or software problem, first try the electronic support systems. If the information available on these systems does not answer your questions, we offer fax and telephone support through our technical support centers, which are staffed by applications engineers.

Electronic Services

Bulletin Board Support

National Instruments has BBS and FTP sites dedicated for 24-hour support with a collection of files and documents to answer most common customer questions. From these sites, you can also download the latest instrument drivers, updates, and example programs. For recorded instructions on how to use the bulletin board and FTP services and for BBS automated information, call 512 795 6990. You can access these services at:

United States: 512 794 5422
Up to 14,400 baud, 8 data bits, 1 stop bit, no parity

United Kingdom: 01635 551422
Up to 9,600 baud, 8 data bits, 1 stop bit, no parity

France: 01 48 65 15 59
Up to 9,600 baud, 8 data bits, 1 stop bit, no parity

FTP Support

To access our FTP site, log on to our Internet host, `ftp.natinst.com`, as `anonymous` and use your Internet address, such as `joesmith@anywhere.com`, as your password. The support files and documents are located in the `/support` directories.

Fax-on-Demand Support

Fax-on-Demand is a 24-hour information retrieval system containing a library of documents on a wide range of technical information. You can access Fax-on-Demand from a touch-tone telephone at 512 418 1111.

E-Mail Support (Currently USA Only)

You can submit technical support questions to the applications engineering team through e-mail at the Internet address listed below. Remember to include your name, address, and phone number so we can contact you with solutions and suggestions.

`support@natinst.com`

Telephone and Fax Support

National Instruments has branch offices all over the world. Use the list below to find the technical support number for your country. If there is no National Instruments office in your country, contact the source from which you purchased your software to obtain support.

Country	Telephone	Fax
Australia	03 9879 5166	03 9879 6277
Austria	0662 45 79 90 0	0662 45 79 90 19
Belgium	02 757 00 20	02 757 03 11
Brazil	011 288 3336	011 288 8528
Canada (Ontario)	905 785 0085	905 785 0086
Canada (Quebec)	514 694 8521	514 694 4399
Denmark	45 76 26 00	45 76 26 02
Finland	09 725 725 11	09 725 725 55
France	01 48 14 24 24	01 48 14 24 14
Germany	089 741 31 30	089 714 60 35
Hong Kong	2645 3186	2686 8505
Israel	03 6120092	03 6120095
Italy	02 413091	02 41309215
Japan	03 5472 2970	03 5472 2977
Korea	02 596 7456	02 596 7455
Mexico	5 520 2635	5 520 3282
Netherlands	0348 433466	0348 430673
Norway	32 84 84 00	32 84 86 00
Singapore	2265886	2265887
Spain	91 640 0085	91 640 0533
Sweden	08 730 49 70	08 730 43 70
Switzerland	056 200 51 51	056 200 51 55
Taiwan	02 377 1200	02 737 4644
United Kingdom	01635 523545	01635 523154
United States	512 795 8248	512 794 5678

Technical Support Form

Photocopy this form and update it each time you make changes to your software or hardware, and use the completed copy of this form as a reference for your current configuration. Completing this form accurately before contacting National Instruments for technical support helps our applications engineers answer your questions more efficiently.

If you are using any National Instruments hardware or software products related to this problem, include the configuration forms from their user manuals. Include additional pages if necessary.

Name _____

Company _____

Address _____

_____

Fax (___) _____Phone (___) _____

Computer brand_____ Model _____Processor_____

Operating system (include version number) _____

Clock speed _____MHz RAM _____MB Display adapter _____

Mouse ___yes ___no Other adapters installed_____

Hard disk capacity _____MB Brand_____

Instruments used _____

_____

National Instruments hardware product model _____ Revision _____

Configuration _____

National Instruments software product _____ Version _____

Configuration _____

The problem is: _____

_____

_____

_____

_____

List any error messages: _____

_____

_____

The following steps reproduce the problem: _____

_____

_____

_____

_____

Documentation Comment Form

National Instruments encourages you to comment on the documentation supplied with our products. This information helps us provide quality products to meet your needs.

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Edition Date: January 1998

Part Number: 320539D-01

Please comment on the completeness, clarity, and organization of the manual.

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If you find errors in the manual, please record the page numbers and describe the errors.

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Thank you for your help.

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Glossary

Prefix	Meanings	Value
m-	milli-	10^{-3}
µ-	micro-	10^{-6}
n-	nano-	10^{-9}

Numbers/Symbols

1D — One-dimensional.

2D — Two-dimensional.

A

ANSI — American National Standards Institute.

application zone — *See* AZ.

array — An ordered, indexed set of data elements of the same type.

asynchronous execution — Mode in which multiple processes share processor time, one executing while the others, for example, wait for interrupts, as while performing device I/O or waiting for a clock tick.

AZ (application zone) — Memory allocation section that holds all data in a VI except execution data.

B

block diagram — Pictorial description or representation of a program or algorithm. In LabVIEW, the block diagram, which consists of executable icons called nodes and wires that carry data between the nodes, is the source code for the virtual instrument. The block diagram resides in the block diagram of the VI.

Boolean controls and indicators	Front panel objects used to manipulate and display or input and output Boolean (True or False) data. Several styles are available, such as switches, buttons and LEDs.
breakpoint	Mode that halts execution when a subVI is called. You set a breakpoint by clicking on the toolbar and then on a node.
broken VI	VI that cannot be compiled or run; signified by a run button with a broken arrow.
Bundle node	Function that creates clusters from various types of elements.

C

C string (CStr)	A series of zero or more unsigned characters, terminated by a zero, used in the C programming language.
Case Structure	Conditional branching control structure, which executes one and only one of its subdiagrams based on its input. It is the combination of the IF THEN ELSE and CASE statements in control flow languages.
cast	To change the type descriptor of a data element without altering the memory image of the data.
chart	*See* scope chart, strip chart, and sweep chart.
CIN source code	Original, uncompiled text code. *See* object code.
cluster	A set of ordered, unindexed data elements of any data type including numeric, Boolean, string, array, or cluster. The elements must be all controls or all indicators.
Code Interface Node	Special block diagram node through which you can link conventional, text-based code to a VI.
code resource	Resource containing executable machine code. You link code resources to LabVIEW through a CIN.
compile	Process that converts high-level code to machine-executable code. LabVIEW automatically compiles VIs before they run for the first time after creation or alteration.
concatenated Pascal string (CPStr)	A list of Pascal-type strings concatenated into a single block of memory.

connector	Part of the VI or function node containing its input and output terminals, through which data passes to and from the node.
control	Front panel object for entering data to a VI interactively or to a subVI programmatically.
control flow	Programming system in which the sequential order of instructions determines execution order. Most conventional text-based programming languages, such as C, Pascal, and BASIC, are control flow languages.
conversion	Changing the type of a data element.
CPStr	*See* concatenated Pascal string.

D

data acquisition	Process of acquiring data, typically from A/D or digital input plug-in boards.
data dependency	Condition in a dataflow programming language in which a node cannot execute until it receives data from another node. *See also* artificial data dependency.
data flow	Programming system consisting of executable nodes in which nodes execute only when they have received all required input data and produce output automatically when they have executed. LabVIEW is a dataflow system.
data space zone	*See* DS zone.
data type descriptor	Code that identifies data types, used in data storage and representation.
diagram window	VI window containing the VI's block diagram code.
dimension	Size and structure attribute of an array.
DS (data space) zone	Memory allocation section that holds VI execution data.

E

empty array	Array that has zero elements, but has a defined data type. For example, an array that has a numeric control in its data display window but has no defined values for any element is an empty numeric array.

EOF	End-of-file. Character offset of the end of file relative to the beginning of the file (the EOF is the size of the file).
executable	A stand-alone piece of code that will run, or execute.
external routine	*See* shared external routine.

F

flattened data	Data of any type that has been converted to a string, usually for writing it to a file.
Formula Node	Node that executes formulas you enter as text. Especially useful for lengthy formulas too cumbersome to build in block diagram form.
function	Built-in execution element, comparable to an operator, function, or statement in a conventional language.

G

G	LabVIEW graphical programming language.

H

handle	Pointer to a pointer to a block of memory; handles reference arrays and strings. An array of strings is a handle to a block of memory containing handles to strings.

I

icon	Graphical representation of a node on a block diagram.
icon pane	Region in the upper right-hand corner of the front panel and block diagram windows that displays the VI icon.
IEEE	Institute of Electrical and Electronic Engineers.
indicator	Front panel object that displays output.
Inf	Digital display value for a floating point representation of infinity.

inplace	Characteristic of an operation whose input and output data can use the same memory space.

L

LabVIEW string (LStr)	The string data type used by LabVIEW block diagrams.

M

matrix	Two-dimensional array.
MB	Megabytes of memory.
MPW	Macintosh Programmer's Workshop.
MSB	Most significant bit.

N

NaN	Digital display value for a floating-point representation of *not-a-number*, typically the result of an undefined operation, such as log(–1).
nodes	Execution elements of a block diagram consisting of functions, structures, and subVIs.

O

object	Generic term for any item on the front panel or block diagram, including controls, nodes, wires, and imported pictures.
object code	Compiled version of source code. Object code is not stand-alone because you must load it into LabVIEW to run it.

P

Pascal string (PStr)	A series of unsigned characters, with the value of the first character indicating the length of the string. Used in the Pascal programming language.

pointer	Variable containing an address. Commonly this address refers to a dynamically-allocated block of memory.
polymorphism	Ability of a node to automatically adjust to data of different representation, type, or structure.
pop up	To call up a special menu by clicking on an object with the right mouse button **(Windows**, **Sun and HP-UX)** or holding down the <command> key while clicking **(Macintosh)**.
pop-up menus	Menus accessed by popping up on an object. Menu options pertain to that object specifically.
portable	Able to compile on any platform that supports LabVIEW.
private data structures	Data structures whose exact format is not described and is usually subject to change.

R

RAM	Random Access Memory.
reentrant execution	Mode in which calls to multiple instances of a subVI can execute in parallel with distinct and separate data storage.
reference	*See* pointer.
relocatable	Able to be moved by the memory manager to a new memory location.
representation	Subtype of the numeric data type, of which there are signed and unsigned byte, word, and long integers, as well as single-, double-, and extended-precision floating-point numbers both real and complex.

S

scalar	Number capable of being represented by a point on a scale. A single value as opposed to an array. Scalar Booleans, strings and clusters are explicitly singular instances of their respective data types.
shared external routine	Subroutine that can be shared by several CIN code resources.

sink terminal	Terminal that absorbs data. Also called a destination terminal.
source code	Original, uncompiled text code.
source terminal	Terminal that emits data.
subVI	VI used in the block diagram of another VI; comparable to a subroutine.

T

terminal	Object or region on a node through which data passes.
top-level VI	VI at the top of the VI hierarchy. This term is used to distinguish the VI from its subVIs.
type descriptor	*See* data type descriptor.

V

vector	One-dimensional array.
virtual instrument (VI)	LabVIEW program; so called because it models the appearance of a physical instrument.

W

wire	Data path between nodes.