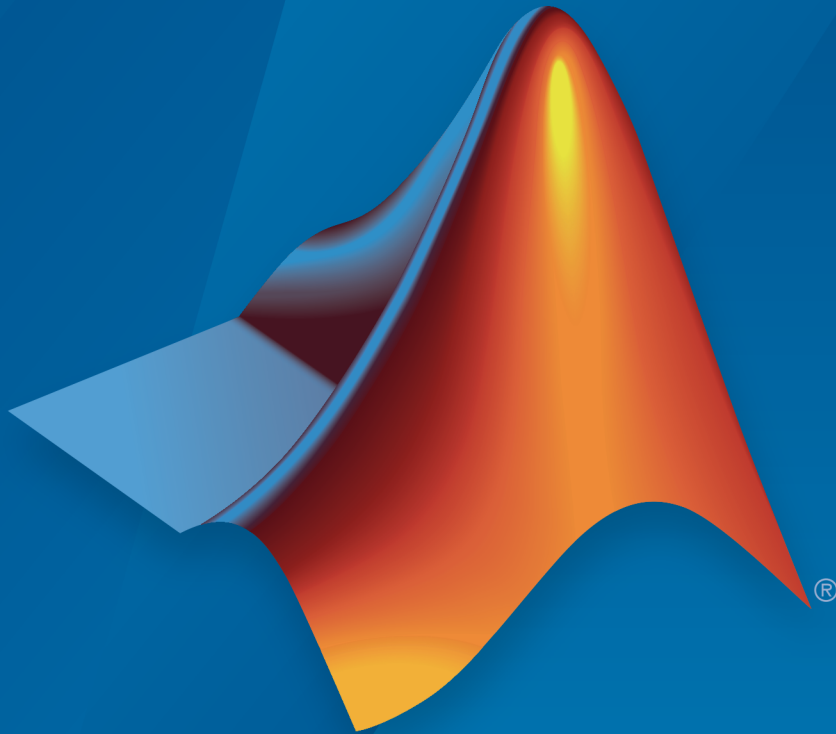


**MATLAB<sup>®</sup> Compiler SDK<sup>™</sup>**

Java User's Guide



**MATLAB<sup>®</sup>**

R2015a

 MathWorks<sup>®</sup>

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*MATLAB<sup>®</sup> Compiler SDK<sup>™</sup> Java User's Guide*

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## Overview

### 1

<b>Product Overview</b> .....	1-2
How Does Java Package Deployment Work? .....	1-2
Limitations of Support .....	1-2
<b>Configure Your Java Environment</b> .....	1-3
Install the Required JDK .....	1-3
Set JAVA_HOME .....	1-4
Set the CLASSPATH .....	1-4
Configure the Native Library Path Variables .....	1-5

## Programming

### 2

<b>MATLAB Compiler SDK and the JVM</b> .....	2-2
<b>Integrate a Java Package into an Application</b> .....	2-3
<b>About the MATLAB Compiler SDK Java API</b> .....	2-8
What Are MATLAB Generated Java Packages and When Should You Create Them? .....	2-8
Understanding the MATLAB Compiler SDK Java API Data Conversion Classes .....	2-8
Automatic Conversion to MATLAB Types .....	2-10
Understanding Function Signatures Generated by the MATLAB Compiler SDK Product .....	2-10
Adding Fields to Data Structures and Data Structure Arrays	2-11
Returning Data from MATLAB to Java .....	2-12

<b>Pass Arguments to and from Java</b> .....	<b>2-13</b>
Format .....	2-13
Manual Conversion of Data Types .....	2-13
Automatic Conversion to a MATLAB Type .....	2-14
Specify Optional Arguments .....	2-16
Handle Return Values .....	2-20
<b>Pass Java Objects by Reference</b> .....	<b>2-25</b>
MATLAB Array .....	2-25
Wrap and Pass Objects to MATLAB .....	2-25
<b>Error Handling</b> .....	<b>2-30</b>
Error Overview .....	2-30
Handling Checked Exceptions .....	2-30
Handling Unchecked Exceptions .....	2-33
Alternatives to Using of System.exit .....	2-35
<b>Manage MATLAB Resources</b> .....	<b>2-36</b>
Why MATLAB Resources Need to be Managed .....	2-36
Creating MATLAB Objects .....	2-36
Disposing of MATLAB Objects .....	2-37
<b>The MATLAB Runtime User Data Interface</b> .....	<b>2-39</b>
<b>Supply Run-Time Profile Information for Parallel Computing</b>	
<b>Toolbox Applications</b> .....	<b>2-40</b>
Step 1: Write Your Parallel Computing Toolbox Code .....	2-40
Step 2: Set the Parallel Computing Toolbox Profile .....	2-41
Step 3: Compile Your Function with the Library Compiler App or the Command Line Compiler .....	2-41
Step 4: Write the Java Driver Application .....	2-42
<b>Dynamically Specify Options to the MATLAB Runtime</b> ...	<b>2-45</b>
What Options Can You Specify? .....	2-45
Setting and Retrieving MATLAB Runtime Option Values Using MWApplication .....	2-45
<b>Data Conversion Between Java and MATLAB</b> .....	<b>2-48</b>
Overview .....	2-48
Call MWArray Methods .....	2-48
Create Buffered Images from a MATLAB Array .....	2-49

<b>Set Java Properties</b> .....	<b>2-50</b>
How to Set Java System Properties .....	<b>2-50</b>
Ensure a Consistent GUI Appearance .....	<b>2-50</b>
<b>Block Execution of Applications that Creates Figures</b> ....	<b>2-52</b>
<b>Ensure Multi-Platform Portability</b> .....	<b>2-54</b>
<b>Deployable Archive Embedding and Extraction</b> .....	<b>2-56</b>
Overview .....	<b>2-56</b>
Use MWComponentOptions Class to Indicate Extraction Options .....	<b>2-56</b>
Use Environment Variables to Indicate Extraction Options .	<b>2-58</b>
For More Information .....	<b>2-59</b>
<b>Explore the Javadoc</b> .....	<b>2-60</b>

## Distribute Integrated Java Applications

### 3

<b>Package Java Applications</b> .....	<b>3-2</b>
<b>About the MATLAB Runtime</b> .....	<b>3-3</b>
How is the MATLAB Runtime Different from MATLAB? ....	<b>3-3</b>
Performance Considerations and the MATLAB Runtime ....	<b>3-4</b>
<b>Download the MATLAB Runtime Installer</b> .....	<b>3-5</b>
<b>Install the MATLAB Runtime</b> .....	<b>3-6</b>
Install the MATLAB Runtime Interactively .....	<b>3-6</b>
Install the MATLAB Runtime Non-Interactively .....	<b>3-7</b>
<b>MATLAB and MATLAB Runtime on Same Machine</b> .....	<b>3-10</b>
Modifying the Path .....	<b>3-10</b>
<b>Multiple MATLAB Runtime on Single Machine</b> .....	<b>3-11</b>
<b>Uninstall MATLAB Runtime</b> .....	<b>3-12</b>
Windows .....	<b>3-12</b>
Linux .....	<b>3-12</b>

**Distribute to End Users**

**4**

**MATLAB Runtime Path Settings for Development and Testing** ..... 4-2

- Path for Java Development on All Platforms ..... 4-2
- Path Modifications Required for Accessibility ..... 4-2
- Windows Settings for Development and Testing ..... 4-2
- Linux Settings for Development and Testing ..... 4-2
- OS X Settings for Development and Testing ..... 4-3

**MATLAB Runtime Path Settings for Run-Time Deployment** ..... 4-4

- General Path Guidelines ..... 4-4
- Path for Java Applications on All Platforms ..... 4-4
- Windows Path for Run-Time Deployment ..... 4-4
- Linux Paths for Run-Time Deployment ..... 4-5
- OS X Paths for Run-Time Deployment ..... 4-5

**Sample Java Applications**

**5**

**Display a MATLAB Plot in a Java Application** ..... 5-2

- Purpose ..... 5-2
- Procedure ..... 5-2

**Create a Java Application with Two MATLAB Functions** .. 5-7

- Purpose ..... 5-7
- Procedure ..... 5-7

**Matrix Math** ..... 5-13

- Purpose ..... 5-13
- MATLAB Functions to Be Encapsulated ..... 5-14
- Understanding the getfactor Program ..... 5-14
- Procedure ..... 5-14

<b>Phone Book</b> .....	5-22
Purpose .....	5-22
Procedure .....	5-22
<b>Pass Java Objects to MATLAB</b> .....	5-28
Purpose .....	5-28
OptimDemo Package .....	5-28
Procedure .....	5-29
<b>Display a MATLAB Plot in a Web Application</b> .....	5-37
Overview .....	5-37
Prerequisites .....	5-37
Locating the Example Files .....	5-38
Build Your Java Package .....	5-39
Compiling Your Java Code .....	5-39
Generating the Web Archive (WAR) File .....	5-40
Running the Web Deployment Example .....	5-40
Using the Web Application .....	5-41

## Deploying a Java Package Over the Web

# 6

<b>About the WebFigures Feature</b> .....	6-2
Supported Renderers for WebFigures .....	6-2
<b>Prepare to Implement WebFigures</b> .....	6-3
Required Products .....	6-3
Assumptions About the Examples .....	6-3
Set DISPLAY on Linux Systems .....	6-4
<b>Implement a Custom WebFigure</b> .....	6-5
Overview .....	6-5
Set Up the Web Server .....	6-5
Create the Default WebFigure .....	6-9
Interact with the Default WebFigure .....	6-10
Create a Custom WebFigure .....	6-11
<b>Advanced Configuration of a WebFigure</b> .....	6-14
Overview .....	6-14
How Do WebFigures Work? .....	6-16

Installing WebFigureService .....	6-17
Getting the WebFigure Object from Your Method .....	6-18
Attach a WebFigure .....	6-19
Using the WebFigure JSP Tag to Reference a WebFigure ..	6-20
Getting an Embeddable String That References a WebFigure Attached to a Cache .....	6-22

## Working with MATLAB Figures and Images

# 7

<b>Roles in Working with Figures and Images .....</b>	<b>7-2</b>
<b>Create and Modify a MATLAB Figure .....</b>	<b>7-3</b>
Preparing a MATLAB Figure for Export .....	7-3
Changing the Figure (Optional) .....	7-3
Exporting the Figure .....	7-4
Cleaning Up the Figure Window .....	7-4
Modify and Export Figure Data .....	7-4
<b>Work with MATLAB Figure and Image Data .....</b>	<b>7-6</b>
For More Comprehensive Examples .....	7-6
Working with Figures .....	7-6
Working with Images .....	7-6

## Creating Scalable Web Applications Using RMI

# 8

<b>Use Remote Method Invocation (RMI) .....</b>	<b>8-2</b>
<b>RMI Prerequisites .....</b>	<b>8-3</b>
<b>Run Client and Server on Same Machine .....</b>	<b>8-4</b>
<b>Run Client and Server on Separate Machines .....</b>	<b>8-7</b>



<b>Why Use Native Cell Arrays and Struct Arrays?</b> .....	8-8
Using Native Types Does Not Require a Client-Side MATLAB Runtime .....	8-8
<b>Native Data Marshaling Prerequisites</b> .....	8-9
<b>Use Native Java Cell and Struct Arrays</b> .....	8-10
Before You Run the Example .....	8-10
Running the Example .....	8-10
<b>Additional RMI Examples</b> .....	8-14

## Troubleshooting

# 9

<b>Common MATLAB Compiler SDK Error Messages</b> .....	9-2
--	-----

## Reference Information for Java

# 10

<b>Requirements for the MATLAB Compiler SDK Java</b>	
<b>Target</b> .....	10-2
System Requirements .....	10-2
Path Modifications Required for Accessibility .....	10-2
Limitations of the MATLAB Compiler SDK Java Target ...	10-3
<b>Data Conversion Rules</b> .....	10-4
Java to MATLAB Conversion .....	10-4
MATLAB to Java Conversion .....	10-5
Unsupported MATLAB Array Types .....	10-7
<b>Programming Interfaces Generated MATLAB Compiler SDK</b> .....	10-8
APIs Based on MATLAB Function Signatures .....	10-8
Standard API .....	10-9
mlx API .....	10-10

Code Fragment: Signatures Generated for the myprimes Example .....	10-10
<b>Share MATLAB Runtime Instances</b> .....	<b>10-12</b>
What Is a Singleton MATLAB Runtime? .....	<b>10-12</b>
Advantages and Disadvantages of Using a Singleton .....	<b>10-12</b>
<b>MWArray Class Specification</b> .....	<b>10-13</b>

## Functions — Alphabetical List

**11**

# Overview

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- “Product Overview” on page 1-2
- “Configure Your Java Environment” on page 1-3

## Product Overview

In this section...
“How Does Java Package Deployment Work?” on page 1-2
“Limitations of Support” on page 1-2

### How Does Java Package Deployment Work?

There are two kinds of deployment:

- Installing the generated packages and setting up support for them on a development machine so that they can be accessed by a developer who seeks to use them in writing a Java application.
- Deploying support for the generated packages when they are accessed at run time on an end user machine.

To accomplish this kind of deployment, you must make sure that the installer you create for the application takes care of supporting the Java packages on the target machine. In general, this means the MATLAB Runtime must be installed, on the target machine. You must also install the compiler generated packages.

---

**Note:** Java packages created with the MATLAB Compiler SDK product are dependent on the version of MATLAB with which they were built.

---

### Limitations of Support

MATLAB Compiler SDK provides a wide variety of support for various Java types and objects. However, MATLAB objects are not supported as inputs or outputs for compiled or deployed functions.

## Configure Your Java Environment

### In this section...

“Install the Required JDK” on page 1-3

“Set JAVA\_HOME” on page 1-4

“Set the CLASSPATH” on page 1-4

“Configure the Native Library Path Variables” on page 1-5

Before you can use the generated Java packages in a Java development environment, you need to ensure that your Java environment is properly configured. You must verify that:

- Your system uses the same version of the Java Developer’s Kit (JDK) as MATLAB.
- JAVA\_HOME is set to the folder containing the system’s JDK installation.
- CLASSPATH contains all of the MATLAB library JAR files and the JAR files for the packages containing your compiled MATLAB code.
- The MATLAB native library paths are properly configured.

---

**Note:** For updated Java system requirements, including versions of Java Developer's Kit (JDK) and Java Runtime Environment (JRE), see the supported compiler page at [http://www.mathworks.com/support/compilers/current\\_release/](http://www.mathworks.com/support/compilers/current_release/).

---

### Install the Required JDK

To install the proper version of the JDK:

- 1 Verify the version of Java your MATLAB installation is using by running the following MATLAB command:  

```
version -java
```
- 2 Download the matching version Java Developer's Kit (JDK) from <http://www.oracle.com/us/technologies/java/standard-edition/overview/index.html>.
- 3 Install the JDK, following the instructions provided by Oracle®.

---

**Note:** If you are not developing applications or compiling MATLAB code, you can use the Java Runtime Environment (JRE) instead of the JDK.

---

## Set JAVA\_HOME

- 1 From the system command prompt, set the system environment variable, `JAVA_HOME`, to point to your JDK installation.

For example on Windows enter `set JAVA_HOME=path_to_Java_install`.

- 2 If you are compiling MATLAB code, verify that MATLAB is reading the correct value of `JAVA_HOME`.

At the MATLAB command prompt, type `getenv JAVA_HOME` to display the value of `JAVA_HOME` in use by MATLAB.

- 3 Verify that the folder containing your Java installation has been added to your system `PATH` environment variable.

For example on Windows enter `set PATH=%PATH%;path_to_Java_install`.

## Set the CLASSPATH

To build and run a Java application that uses a MATLAB Compiler SDK generated component, the system must locate:

- JAR files containing the MATLAB libraries
- Packages that you have developed and built

Java classes compiled with MATLAB Compiler SDK use classes contained in the `com.mathworks.toolbox.javabuilder` package. To use the compiled classes, you need to include a file called `javabuilder.jar` on the Java class path. You can find this file in one of the following folders:

MATLAB installed on your system	<code>matlabroot/toolbox/javabuilder/jar</code>
MATLAB Runtime installed on your system	<code>mcrroot/toolbox/javabuilder/jar</code>

---

**Note:** `matlabroot` refers to the root folder into which the MATLAB installer has placed the MATLAB files. `mcrroot` refers to the root folder under which MATLAB Runtime is installed.

---

In addition, you need to add to the JAR files created by the compiler to the class path.

## Configure the Native Library Path Variables

The operating system uses the native library path to locate native libraries that are needed to run your Java class. See the following list of variable names according to operating system:

Windows®	PATH
Linux®	LD_LIBRARY_PATH
Macintosh	DYLD_LIBRARY_PATH

The native MATLAB or MATLAB Runtime files needed to execute the compiled MATLAB functions called from the Java code must be included on the paths listed by your system's native library path variable.





# Programming

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- “MATLAB Compiler SDK and the JVM” on page 2-2
- “Integrate a Java Package into an Application” on page 2-3
- “About the MATLAB Compiler SDK Java API” on page 2-8
- “Pass Arguments to and from Java” on page 2-13
- “Pass Java Objects by Reference” on page 2-25
- “Error Handling” on page 2-30
- “Manage MATLAB Resources” on page 2-36
- “The MATLAB Runtime User Data Interface” on page 2-39
- “Supply Run-Time Profile Information for Parallel Computing Toolbox Applications” on page 2-40
- “Dynamically Specify Options to the MATLAB Runtime” on page 2-45
- “Data Conversion Between Java and MATLAB” on page 2-48
- “Set Java Properties” on page 2-50
- “Block Execution of Applications that Creates Figures” on page 2-52
- “Ensure Multi-Platform Portability” on page 2-54
- “Deployable Archive Embedding and Extraction” on page 2-56
- “Explore the Javadoc” on page 2-60

---

**Note:** For examples of these tasks, see the sample Java applications in this documentation.

For information about deploying your application after you complete these tasks, see “How Does Java Package Deployment Work?” on page 1-2.

---

# MATLAB Compiler SDK and the JVM

Packages produced by MATLAB Compiler SDK use Java Native Interface (JNI) to interact with the MATLAB Runtime.

When the first MATLAB Compiler SDK object is instantiated:

- 1 Dependent MATLAB Compiler SDK classes are loaded.
- 2 A series of shared libraries forming the JNI bridge from the generated package to the MATLAB Runtime are loaded.
- 3 The MATLAB Runtime is initialized by creating an instance of a C++ class called `mcrInstance`.
- 4 The MATLAB-Java interface establishes a connection to the JVM by calling the JNI method `AttachCurrentThread`.
- 5 `AttachCurrentThread` creates a class loader that loads all classes needed by MATLAB code utilizing the MATLAB-Java interface.
- 6 The MATLAB Runtime C++ core allocates resources for the arrays created by the Java API.

As you create `MWArray` objects to interact with the MATLAB Runtime, the JVM creates a wrapper object for the MATLAB `mxArray` object. The MATLAB Runtime C++ core allocates the actual resources to store the `mxArray` object. This has an impact on how the JVM frees up resources used by your application. Most of the resources used when interacting with MATLAB are created by the MATLAB Runtime C++ core. The JVM only knows about the MATLAB resources through the JNI wrappers created for them. Because of this, the JVM does not know the size of the resources being consumed and cannot effectively manage them using its built in garbage collector. The JVM also does not manage the threads used by the MATLAB Runtime and cannot clean them up.

All of the MATLAB Compiler SDK classes have static methods to properly dispose of their resources. The disposal methods trigger the freeing of the underlying resources in the MATLAB Runtime C++ core. Not properly disposing of MATLAB Compiler SDK objects can result in unpredictable behavior and may look like your application has a memory leak.

## Integrate a Java Package into an Application

This example shows how to invoke a MATLAB generated method in a Java application.

To create a Java application that calls a MATLAB generated method:

**1** Install the MATLAB Runtime and generated JAR files in one of the following ways:

- Run the installer generated by MATLAB. It is located in the `for_redistribution` folder of the deployment project.

Doing so automatically installs the MATLAB Runtime from the web and places the generated JAR files onto your computer.

- Manually install the MATLAB Runtime and the generated JAR files onto your development system.

You can download the MATLAB Runtime installer from <http://www.mathworks.com/products/compiler/mcr>. The generated JAR files are located in the MATLAB deployment project's `for_testing` folder.

**2** In the folder containing the generated JAR files, create a new file called `getmagic.java`.

**3** Using a text editor, open `getmagic.java`.

**4** Place the following as the first line in the file.

```
import com.mathworks.toolbox.javabuilder.*;
```

This statement imports the MATLAB support classes.

**5** Place the following line after the first import statement.

```
import makesqr.*;
```

This statement imports the classes generated by the compiler.

**6** Add the following class definition.

```
class getmagic
{
}
```

This class has a single main method that calls the generated class.

**7** Add the `main()` method to the application.

```
public static void main(String[] args)
```

```
{  
}
```

- 8** Add the following code to the top of the `main()` method.

```
MWNumericArray n = null;  
Object[] result = null;  
Class1 theMagic = null;
```

This initializes the variables used by the application.

- *n* is an instance of the MATLAB `MWNumericArray` class that MATLAB uses for its internal data format.
  - *result* is a generic Java object that holds the results of the call to MATLAB.
  - *theMagic* is an instance class generated from the MATLAB function.
- 9** Add the following code after the variable initialization.

```
if (args.length == 0)  
{  
    System.out.println("Error: must input a positive integer");  
    return;  
}
```

This is a simple check to ensure that the required command-line argument was passed to the application.

- 10** Add a `try/catch/finally` block after the argument check.
- 11** In the `try` section of the `try/catch/finally` block, add the following code.

```
n = new MWNumericArray(Double.valueOf(args[0]), MWClassID.DOUBLE);
```

The code instantiates an instance of `MWNumericArray` and populates it with a 1-by-1 array containing the integer passed to the application on the command line. The value is converted to a `Double` because that is the most direct mapping between the Java and MATLAB internal data representation.

- 12** After the code instantiating the input parameter, add the following to instantiate the class generated from MATLAB.

```
theMagic = new Class1();
```

The constructor for the generated class handles all of the setup required to start the MATLAB Runtime and populate it with the required MATLAB code.

- 13** Using the newly instantiated object, call the MATLAB function.

```

result = theMagic.makesqr(1, n);
System.out.println(result[0]);

```

- 14** Add the following `catch` section to the `try/catch/finally` block to handle any exceptions that might be thrown.

```

catch (Exception e)
{
    System.out.println("Exception: " + e.toString());
}

```

- 15** Add the following `finally` section to the `try/catch/finally` block to clean up any resources.

```

finally
{
    MWArray.disposeArray(n);
    MWArray.disposeArray(result);
    theMagic.dispose();
}

```

The `disposeArray()` and `dispose()` methods clean up the resources used by the generated MATLAB code.

- 16** Save the Java file.

The completed Java file should resemble the following.

```

import com.mathworks.toolbox.javabuilder.*;
import makesqr.*;

class getmagic
{
    public static void main(String[] args)
    {
        MWNumericArray n = null;
        Object[] result = null;
        Class1 theMagic = null;

        if (args.length == 0)
        {
            System.out.println("Error: must input a positive integer");
            return;
        }

        try

```

```

    {
        n = new MWNumericArray(Double.valueOf(args[0]),
                               MWCClassID.DOUBLE);

        theMagic = new Class1();

        result = theMagic.makesqr(1, n);
        System.out.println(result[0]);
    }
    catch (Exception e)
    {
        System.out.println("Exception: " + e.toString());
    }
    finally
    {
        MWArray.disposeArray(n);
        MWArray.disposeArray(result);
        theMagic.dispose();
    }
}
}

```

- 17 Use the system's command line to navigate to the folder where you installed the generated Java package and saved the new Java file.
- 18 Compile the Java application using `javac`.

```
javac -classpath "mcrroot\toolbox\javabuilder\jar\javabuilder.jar";.\makesqr.jar .\
```

---

**Note:** On UNIX<sup>®</sup> platforms, use colon (:) as the class path delimiter instead of semicolon (;).

---

*mcrroot* is the path to where the MATLAB Runtime is installed on your system. If you have MATLAB installed on your system instead, you can use the path to your MATLAB installation.

- 19 From the system's command prompt, run the application.

```

java -classpath .;"c:\Program Files\MATLAB\MATLAB Compiler Runtime\v82\toolbox\java
17 24 1 8 15
23 5 7 14 16
4 6 13 20 22
10 12 19 21 3
11 18 25 2 9

```

You must be sure to place a dot (.) in the first position of the class path. If it not, you get a message stating that Java cannot load the class.

---

**Note:** On UNIX platforms, use colon (:) as the class path delimiter instead of semicolon (;).

---

*mcrroot* is the path to where the MATLAB Runtime is installed on your system. If you have MATLAB installed on your system instead, you can use the path to your MATLAB installation.

To follow up on this example:

- Try installing the new application on a different computer.
- Try building an installer for the application.
- Try integrating a package that consists of multiple functions.

## About the MATLAB Compiler SDK Java API

**In this section...**

“What Are MATLAB Generated Java Packages and When Should You Create Them?” on page 2-8

“Understanding the MATLAB Compiler SDK Java API Data Conversion Classes” on page 2-8

“Automatic Conversion to MATLAB Types” on page 2-10

“Understanding Function Signatures Generated by the MATLAB Compiler SDK Product” on page 2-10

“Adding Fields to Data Structures and Data Structure Arrays” on page 2-11

“Returning Data from MATLAB to Java” on page 2-12

### What Are MATLAB Generated Java Packages and When Should You Create Them?

MATLAB generated Java packages include one or more Java classes that wrap your MATLAB functions. The classes provide methods that allow you to call the functions as you would any other Java method. In addition, the generated classes provide all of the functionality required to manage the MATLAB Runtime required to run the MATLAB functions.

The compiler encrypts your MATLAB functions and generates a Java wrapper around them so that they behave just like any other Java class. You can deploy generated packages to enterprise or Web environments, sharing them with anyone running a Web browser and having the MATLAB Runtime installed.

For development on Linux platforms, Java packages and applications provide portable and scalable solutions for applications in large-scale enterprise or Web environments.

### Understanding the MATLAB Compiler SDK Java API Data Conversion Classes

When writing your Java application, you can represent your data using objects of any of the data conversion classes. Alternatively, you can use standard Java data types and objects.



The data conversion classes are built as a class hierarchy that represents the major MATLAB array types.

---

**Note:** This discussion provides conceptual information about the classes. For details, see `com.mathworks.toolbox.javabuilder`.

This discussion assumes you have a working knowledge of the Java programming language and the Java Software Developer's Kit (SDK). This is not intended to be a discussion on how to program in Java. Refer to the documentation that came with your Java SDK for general programming information.

---

### Overview of Classes and Methods in the Data Conversion Class Hierarchy

The root of the data conversion class hierarchy is the `MWArray` abstract class. The `MWArray` class has the following subclasses representing the major MATLAB types: `MWNumericArray`, `MWLogicalArray`, `MWCharArray`, `MWCellArray`, and `MWStructArray`.

Each subclass stores a reference to a native MATLAB array of that type. Each class provides constructors and a basic set of methods for accessing the underlying array's properties and data. To be specific, `MWArray` and the classes derived from `MWArray` provide the following:

- Constructors and finalizers to instantiate and dispose of MATLAB arrays
- `get` and `set` methods to read and write the array data
- Methods to identify properties of the array
- Comparison methods to test the equality or order of the array
- Conversion methods to convert to other data types

### Advantage of Using Data Conversion Classes

The `MWArray` data conversion classes let you pass native type parameters directly without using explicit data conversion. If you pass the same array frequently, you might improve the performance of your program by storing the array in an instance of one of the `MWArray` subclasses.

### Automatic Conversion to MATLAB Types

---

**Note:** Because the conversion process is automatic (in most cases), you do not need to understand the conversion process to pass and return arguments with MATLAB Compiler SDK generated methods.

---

When you pass an `MWArray` instance as an input argument, the encapsulated MATLAB array is passed directly to the method being called.

In contrast, if your code uses a native Java primitive or array as an input parameter, the compiler converts it to an instance of the appropriate `MWArray` class before it is passed to the method. The compiler can convert any Java string, numeric type, or any multidimensional array of these types to an appropriate `MWArray` type, using its data conversion rules. See “Data Conversion Rules” on page 10-4 for a list of all the data types that are supported along with their equivalent types in MATLAB.

The conversion rules apply not only when calling your own methods, but also when calling constructors and factory methods belonging to the `MWArray` classes.

---

**Note:** To work directly with cell arrays and data structures in native Java, see “Use Native Java Cell and Struct Arrays” on page 8-10 for information and comprehensive examples.

---

### Understanding Function Signatures Generated by the MATLAB Compiler SDK Product

The Java programming language now supports optional function arguments in the way that MATLAB does with `varargin` and `varargout`. To support this feature of MATLAB, the compiler generates a single overloaded Java method that accommodates any number of input arguments. This behavior is an enhancement over previous versions of `varargin` support that only handled a limited number of arguments.

---

**Note:** In addition to handling optional function arguments, the overloaded Java methods that wrap MATLAB functions handle data conversion. See “Automatic Conversion to MATLAB Types” on page 2-10 for more details.

---

## Understanding MATLAB Function Signatures

As background, recall that the generic MATLAB function has the following structure:

```
function [Out1, Out2, ..., varargout]=  
        foo(In1, In2, ..., varargin)
```

To the *left* of the equal sign, the function specifies a set of explicit and optional return arguments.

To the *right* of the equal sign, the function lists explicit *input* arguments followed by one or more optional arguments.

Each argument represents a MATLAB type. When you include the `varargin` or `varargout` argument, you can specify any number of inputs or outputs beyond the ones that are explicitly declared.

## Overloaded Methods in Java That Encapsulate MATLAB Code

When the MATLAB Compiler SDK product encapsulates your MATLAB code, it creates an overloaded method that implements the MATLAB functions. This overloaded method corresponds to a call to the generic MATLAB function for each combination of the possible number and type of input arguments.

In addition to encapsulating input arguments, the compiler creates another method, which represents the output arguments, or return values, of the MATLAB function. This additional overloaded method takes care of return values for the encapsulated MATLAB function. This method of encapsulating the information about return values simulates the `m1x` interface generated for the C/C++ MATLAB Compiler SDK target.

These overloaded methods are called the standard interface and the `m1x` interface. See “Programming Interfaces Generated MATLAB Compiler SDK” on page 10-8 for details.

## Adding Fields to Data Structures and Data Structure Arrays

When adding fields to data structures and data structure arrays, do so using standard programming techniques. Do not use the `set` command as a shortcut.

### Returning Data from MATLAB to Java

All data returned from a method coded in MATLAB is passed as an instance of the appropriate `MWArray` subclass. For example, a MATLAB cell array is returned to the Java application as an `MWCellArray` object.

Return data is *not* converted to a Java type. If you choose to use a Java type, you must convert to that type using the `toArray` method of the `MWArray` subclass to which the return data belongs.

---

**Note:** To work directly with cell arrays and data structures in native Java, see “Use Native Java Cell and Struct Arrays” on page 8-10 for information and comprehensive examples.

---

## Pass Arguments to and from Java

### In this section...

“Format” on page 2-13

“Manual Conversion of Data Types” on page 2-13

“Automatic Conversion to a MATLAB Type” on page 2-14

“Specify Optional Arguments” on page 2-16

“Handle Return Values” on page 2-20

### Format

When you invoke a method on a generated class, the input arguments received by the method must be in the MATLAB internal array format. You can either convert them yourself within the calling program, or pass the arguments as Java data types, which are then automatically converted by the calling mechanism.

To convert them yourself, use instances of the `MWArray` classes; in this case you are using *manual conversion*. Storing your data using the classes and data types defined in the Java language means that you are relying on *automatic conversion*. Most likely, you will use a combination of manual and automatic conversion.

### Manual Conversion of Data Types

To manually convert to one of the standard MATLAB data types, use the `MWArray` data conversion classes provided by the compiler. For class reference and usage information, see the `com.mathworks.toolbox.javabuilder` package.

#### Using `MWNumericArray`

The Magic Square example (“Integrate a Java Package into an Application” on page 2-3) exemplifies manual conversion. The following code fragment from that program shows a `java.lang.Double` argument that is converted to an `MWNumericArray` type that can be used by the MATLAB function without further conversion:

```
n = new MWNumericArray(Double.valueOf(args[0]),  
                        MWClassID.DOUBLE);
```

```
theMagic = new Class1();  
result = theMagic.makesqr(1, n);
```

### Passing an MArray

This example constructs an `MWNumericArray` of type `MWClassID.DOUBLE`. The call to `myprimes` passes the number of outputs, 1, and the `MWNumericArray`, `x`:

```
x = new MWNumericArray(n, MWClassID.DOUBLE);  
cls = new myclass();  
y = cls.myprimes(1, x);
```

The Java bridge converts the `MWNumericArray` object to a MATLAB scalar `double` to pass to the MATLAB function.

## Automatic Conversion to a MATLAB Type

When passing an argument only a small number of times, it is usually just as efficient to pass a primitive Java type or object. In this case, the calling mechanism converts the data for you into an equivalent MATLAB type.

For instance, either of the following Java types would be automatically converted to the MATLAB `double` type:

- A Java `double` primitive
- An object of class `java.lang.Double`

For reference information about data conversion (tables showing each Java type along with its converted MATLAB type, and each MATLAB type with its converted Java type), see “Data Conversion Rules” on page 10-4.

### Automatic Data Conversion

When calling the `makesqr` method used in the `getmagic` application, you could construct an object of type `MWNumericArray`. Doing so would be an example of manual conversion. Instead, you could rely on automatic conversion, as shown in the following code fragment:

```
result = M.makesqr(1, arg[0]);
```

In this case, a Java `double` is passed as `arg[0]`.

Here is another example:

```
result = theFourier.plotfft(3, data, new Double(interval));
```

In this Java statement, the third argument is of type `java.lang.Double`. According to conversion rules, the `java.lang.Double` automatically converts to a MATLAB 1-by-1 `double` array.

### Passing a Java Double Object

The example calls the `myprimes` method with two arguments. The first specifies the number of arguments to return. The second is an object of class `java.lang.Double` that passes the one data input to `myprimes`.

```
cls = new myclass();  
y = cls.myprimes(1, new Double((double)n));
```

This second argument is converted to a MATLAB 1-by-1 `double` array, as required by the MATLAB function. This is the default conversion rule for `java.lang.Double`.

### Passing an MWArray

This example constructs an `MWNumericArray` of type `MWClassID.DOUBLE`. The call to `myprimes` passes the number of outputs, 1, and the `MWNumericArray`, `x`.

```
x = new MWNumericArray(n, MWClassID.DOUBLE);  
cls = new myclass();  
y = cls.myprimes(1, x);
```

The compiler converts the `MWNumericArray` object to a MATLAB scalar `double` to pass to the MATLAB function.

### Calling MWArray Methods

The conversion rules apply not only when calling your own methods, but also when calling constructors and factory methods belonging to the `MWArray` classes.

For example, the following code fragment calls the constructor for the `MWNumericArray` class with a Java `double` as the input argument:

```
double Adata = 24;  
MWNumericArray A = new MWnumericArray(Adata);
```

```
System.out.println("Array A is of type " + A.classID());
```

The compiler converts the input argument to an instance of `MWNumericArray`, with a `ClassID` property of `MWClassID.DOUBLE`. This `MWNumericArray` object is the equivalent of a MATLAB 1-by-1 `double` array.

When you run this example, the result is as follows:

```
Array A is of type double
```

### Changing the Default by Specifying the Type

When calling an `MWArray` class method constructor, supplying a specific data type causes the MATLAB Compiler SDK product to convert to that type instead of the default.

For example, in the following code fragment, the code specifies that `A` should be constructed as a MATLAB 1-by-1 16-bit integer array:

```
double Adata = 24;
MWNumericArray A = new MWNumericArray(Adata, MWClassID.INT16);
System.out.println("Array A is of type " + A.classID());
```

When you run this example, the result is as follows:

```
Array A is of type int16
```

### Specify Optional Arguments

So far, the examples have not used MATLAB functions that have `varargin` or `varargout` arguments. Consider the following MATLAB function:

```
function y = mysum(varargin)
y = sum([varargin{:}]);
```

This function returns the sum of the inputs. The inputs are provided as a `varargin` argument, which means that the caller can specify any number of inputs to the function. The result is returned as a scalar `double`.

### Pass Variable Numbers of Inputs

The MATLAB Compiler SDK product generates a Java interface to this function as follows:



```

/* mlx interface - List version*/
public void mysum(List lhs, List rhs)
                    throws MWException
{
    (implementation omitted)
}
/* mlx interface - Array version*/
public void mysum(Object[] lhs, Object[] rhs)
                    throws MWException
{
    (implementation omitted)
}

/* standard interface - no inputs */
public Object[] mysum(int nargout) throws MWException
{
    (implementation omitted)
}

/* standard interface - variable inputs */
public Object[] mysum(int nargout, Object varargin)
                    throws MWException
{
    (implementation omitted)
}

```

In all cases, the `varargin` argument is passed as type `Object`. This lets you provide any number of inputs in the form of an array of `Object`, that is `Object[]`, and the contents of this array are passed to the compiled MATLAB function in the order in which they appear in the array. Here is an example of how you might use the `mysum` method in a Java program:

```

public double getsum(double[] vals) throws MWException
{
    myclass cls = null;
    Object[] x = {vals};
    Object[] y = null;

    try
    {
        cls = new myclass();
        y = cls.mysum(1, x);
        return ((MWNumericArray)y[0]).getDouble(1);
    }
}

```

```
    finally
    {
        MWArray.disposeArray(y);
        if (cls != null)
            cls.dispose();
    }
}
```

In this example, an `Object` array of length 1 is created and initialized with a reference to the supplied `double` array. This argument is passed to the `mysum` method. The result is known to be a scalar `double`, so the code returns this `double` value with the statement:

```
return ((MWNumericArray)y[0]).getDouble(1);
```

Cast the return value to `MWNumericArray` and invoke the `getDouble(int)` method to return the first element in the array as a primitive `double` value.

### Pass Array Inputs

The next example performs a more general calculation:

```
public double getsum(Object[] vals) throws MWException
{
    myclass cls = null;
    Object[] x = null;
    Object[] y = null;

    try
    {
        x = new Object[vals.length];
        for (int i = 0; i < vals.length; i++)
            x[i] = new MWNumericArray(vals[i], MWClassID.DOUBLE);

        cls = new myclass();
        y = cls.mysum(1, x);
        return ((MWNumericArray)y[0]).getDouble(1);
    }
    finally
    {
        MWArray.disposeArray(x);
        MWArray.disposeArray(y);
        if (cls != null)
            cls.dispose();
    }
}
```

```
    }
}
```

This version of `getsum` takes an array of `Object` as input and converts each value to a `double` array. The list of `double` arrays is then passed to the `mysum` function, where it calculates the total sum of each input array.

### Pass a Variable Number of Outputs

When present, `varargout` arguments are handled in the same way that `varargin` arguments are handled. Consider the following MATLAB function:

```
function varargout = randvectors

for i=1:nargout
    varargout{i} = rand(1, i);
end
```

This function returns a list of random `double` vectors such that the length of the *i*th vector is equal to *i*. The MATLAB Compiler™ product generates a Java interface to this function as follows:

```
/* mlx interface - List version */
public void randvectors(List lhs, List rhs) throws MWException
{
    (implementation omitted)
}
/* mlx interface - Array version */
public void randvectors(Object[] lhs,
    Object[] rhs) throws MWException
{
    (implementation omitted)
}
/* Standard interface - no inputs*/
public Object[] randvectors(int nargout) throws MWException
{
    (implementation omitted)
}
```

### Pass Optional Arguments with the Standard Interface

Here is one way to use the `randvectors` method in a Java program:

```
public double[][] getrandvectors(int n) throws MWException
```

```
{
  myclass cls = null;
  Object[] y = null;

  try
  {
    cls = new myclass();
    y = cls.randvectors(n);
    double[][] ret = new double[y.length][];

    for (int i = 0; i < y.length; i++)
      ret[i] = (double[])((MArray)y[i]).getData();
    return ret;
  }

  finally
  {
    MArray.disposeArray(y);
    if (cls != null)
      cls.dispose();
  }
}
```

The `getrandvectors` method returns a two-dimensional `double` array with a triangular structure. The length of the `i`th row equals `i`. Such arrays are commonly referred to as *jagged* arrays. Jagged arrays are easily supported in Java because a Java matrix is just an array of arrays.

### Handle Return Values

The previous examples used the fact that you knew the type and dimensionality of the output argument. In the case that this information is unknown, or can vary (as is possible in MATLAB programming), the code that calls the method might need to query the type and dimensionality of the output arguments.

There are several ways to do this. Do one of the following:

- Use reflection support in the Java language to query any object for its type.
- Use several methods provided by the `MArray` class to query information about the underlying MATLAB array.
- Coercing to a specific type using the `toTypeArray` methods.

## Use Java Reflection to Determine Type and Dimensionality

This code sample calls the `myprimes` method, and then determines the type using reflection. The example assumes that the output is returned as a numeric matrix but the exact numeric type is unknown.

```
public void getprimes(int n) throws MWException
{
    myclass cls = null;
    Object[] y = null;

    try
    {
        cls = new myclass();
        y = cls.myprimes(1, new Double((double)n));
        Object a = ((MWArray)y[0]).toArray();

        if (a instanceof double[][])
        {
            double[][] x = (double[][])a;

            /* (do something with x...) */
        }

        else if (a instanceof float[][])
        {
            float[][] x = (float[][])a;

            /* (do something with x...) */
        }

        else if (a instanceof int[][])
        {
            int[][] x = (int[][])a;

            /* (do something with x...) */
        }

        else if (a instanceof long[][])
        {
            long[][] x = (long[][])a;

            /* (do something with x...) */
        }
    }
}
```

```
    else if (a instanceof short[][])
    {
        short[][] x = (short[][])a;

        /* (do something with x...) */
    }

    else if (a instanceof byte[][])
    {
        byte[][] x = (byte[][])a;

        /* (do something with x...) */
    }

    else
    {
        throw new MWException(
            "Bad type returned from myprimes");
    }
}
```

This example uses the `toArray` method to return a Java primitive array representing the underlying MATLAB array. The `toArray` method works just like `getData` in the previous examples, except that the returned array has the same dimensionality as the underlying MATLAB array.

### Use `MWArray Query` to Determine Type and Dimensionality

The next example uses the `MWArray classID` method to determine the type of the underlying MATLAB array. It also checks the dimensionality by calling `numberOfDimensions`. If any unexpected information is returned, an exception is thrown. It then checks the `MWClassID` and processes the array accordingly.

```
public void getprimes(int n) throws MWException
{
    myclass cls = null;
    Object[] y = null;

    try
    {
        cls = new myclass();
        y = cls.myprimes(1, new Double((double)n));
        MWClassID clsid = ((MWArray)y[0]).classID();
    }
}
```

```
if (!clsid.isNumeric() ||
    ((MWArray)y[0]).numberOfDimensions() != 2)
{
    throw new MWException("Bad type
                           returned from myprimes");
}

if (clsid == MWClassID.DOUBLE)
{
    double[][] x = (double[][])((MWArray)y[0]).toArray();

    /* (do something with x...) */
}

else if (clsid == MWClassID.SINGLE)
{
    float[][] x = (float[][])((MWArray)y[0]).toArray();

    /* (do something with x...) */
}

else if (clsid == MWClassID.INT32 ||
         clsid == MWClassID.UINT32)
{
    int[][] x = (int[][])((MWArray)y[0]).toArray();

    /* (do something with x...) */
}

else if (clsid == MWClassID.INT64 ||
         clsid == MWClassID.UINT64)
{
    long[][] x = (long[][])((MWArray)y[0]).toArray();

    /* (do something with x...) */
}

else if (clsid == MWClassID.INT16 ||
         clsid == MWClassID.UINT16)
{
    short[][] x = (short[][])((MWArray)y[0]).toArray();

    /* (do something with x...) */
}
```

```
    }  
  
    else if (clsid == MWClassID.INT8 ||  
            clsid == MWClassID.UINT8)  
    {  
        byte[][] x = (byte[][])((MWArray)y[0]).toArray();  
  
        /* (do something with x...) */  
    }  
}  
finally  
{  
    MWArray.disposeArray(y);  
    if (cls != null)  
        cls.dispose();  
}  
}
```

### **Use toTypeArray Methods to Determine Type and Dimensionality**

The next example demonstrates how you can coerce or force data to a specified numeric type by invoking any of the *toTypeArray* methods. These methods return an array of Java types matching the primitive type specified in the name of the called method. The data is coerced or forced to the primitive type specified in the method name. Note that when using these methods, data will be truncated when needed to allow conformance to the specified data type.

```
Object results = null;  
try {  
    // call a compiled MATLAB function  
    results = myobject.myfunction(2);  
  
    // first output is known to be a numeric matrix  
    MWArray resultA = (MWNumericArray) results[0];  
    double[][] a = (double[][]) resultA.toDoubleArray();  
  
    // second output is known to be  
    // a 3-dimensional numeric array  
    MWArray resultB = (MWNumericArray) results[1];  
    Int[][][] b = (Int[][][]) resultB.toIntArray();  
}  
finally {  
    MWArray.disposeArray(results);  
}
```



# Pass Java Objects by Reference

## In this section...

“MATLAB Array” on page 2-25

“Wrap and Pass Objects to MATLAB ” on page 2-25

## MATLAB Array

`MWJavaObjectRef`, a special subclass of `MWArray`, can be used to create a MATLAB array that references Java objects. For detailed usage information on this class, constructor, and associated methods, see the `MWJavaObjectRef` page in the Javadoc or search for `MWJavaObjectRef` in the MATLAB Help browser **Search** field.

You can find the Javadoc at `matlabroot/help/javabuilder/MWArrayAPI` in your product installation.

## Wrap and Pass Objects to MATLAB

You can create a MATLAB code wrapper around Java objects using `MWJavaObjectRef`. Using this technique, you can pass objects by reference to MATLAB functions, clone a Java object inside a generated package, as well as perform other object marshaling specific to the MATLAB Compiler SDK product. The examples in this section present some common use cases.

### Passing a Java Object into a MATLAB Compiler SDK Java Method

To pass an object into a MATLAB Compiler SDK Java method:

- 1 Use `MWJavaObjectRef` to wrap your object.
- 2 Pass your object to a MATLAB function. For example:

```
/* Create an object */
java.util.Hashtable<String,Integer> hash =
    new java.util.Hashtable<String,Integer>();
hash.put("One", 1);
hash.put("Two", 2);
System.out.println("hash: ");
System.out.println(hash.toString());

/* Create a MWJavaObjectRef to wrap this object */
```

```
origRef = new MWJavaObjectRef(hash);

/* Pass it to an MATLAB function that lists its methods, etc */
result = theComponent.displayObj(1, origRef);
MWArray.disposeArray(origRef);
```

### Cloning an Object

You can also use `MWJavaObjectRef` to clone an object. Continuing with the example in “Passing a Java Object into a MATLAB Compiler SDK Java Method” on page 2-25, do the following:

- 1 Add to the original hash.
- 2 Clone the object.
- 3 (Optional) Continue to add items to each copy. For example:

```
origRef = new MWJavaObjectRef(hash);
System.out.println("hash:");
System.out.println(hash.toString());
result = theComponent.addToHash(1, origRef);

outputRef = (MWJavaObjectRef)result[0];

/* We can typecheck that the reference contains a      */
/*      Hashtable but not <String,Integer>;          */
/* this can cause issues if we get a Hashtable<wrong,wrong>. */
java.util.Hashtable<String, Integer> outHash =
    (java.util.Hashtable<String,Integer>)(outputRef.get());

/* We've added items to the original hash, cloned it, */
/* then added items to each copy */
System.out.println("hash:");
System.out.println(hash.toString());
System.out.println("outHash:");
System.out.println(outHash.toString());
```

For reference, here is the source code for `addToHash.m`:

#### **addToHash.m**

```
function h2 = addToHash(h)

% Validate input
if ~isa(h,'java.util.Hashtable')
    error('addToHash:IncorrectType', ...
        'addToHash expects a java.util.Hashtable');
end

% Add an item
h.put('From MATLAB',12);
% Clone the Hashtable and add items to both resulting objects
```

```
h2 = h.clone();
h.put('Orig',20);
h2.put('Clone',21);
```

### Passing a Date into a Method and Getting a Date from a Method

In addition to passing in created objects, as in “Passing a Java Object into a MATLAB Compiler SDK Java Method” on page 2-25, you can also use `MWJavaObjectRef` to pass in Java utility objects such as `java.util.date`. To do so, perform the following steps:

- 1 Get the current date and time using the Java object `java.util.date`.
- 2 Create an instance of `MWJavaObjectRef` in which to wrap the Java object.
- 3 Pass it to an MATLAB function that performs further processing, such as `nextWeek.m`. For example:

```
/* Get the current date and time */
java.util.Date nowDate = new java.util.Date();
System.out.println("nowDate:");
System.out.println(nowDate.toString());

/* Create a MWJavaObjectRef to wrap this object */
origRef = new MWJavaObjectRef(nowDate);

/* Pass it to a MATLAB function that calculates one week */
/* in the future */
result = theComponent.nextWeek(1, origRef);

outputRef = (MWJavaObjectRef)result[0];
java.util.Date nextWeekDate =
    (java.util.Date)outputRef.get();
System.out.println("nextWeekDate:");
System.out.println(nextWeekDate.toString());
```

For reference, here is the source code for `nextWeek.m`:

#### `nextWeek.m`

```
function nextWeekDate = nextWeek(nowDate)

% Validate input
if ~isa(nowDate,'java.util.Date')
    error('nextWeekDate:IncorrectType', ...
        'nextWeekDate expects a java.util.Date');
end

% Use java.util.Calendar to calculate one week later
% than the supplied
% java.util.Date
cal = java.util.Calendar.getInstance();
cal.setTime(nowDate);
cal.add(java.util.Calendar.DAY_OF_MONTH, 7);
```

```
nextWeekDate = cal.getTime();
```

### Returning Java Objects Using `unwrapJavaObjectRefs`

If you want actual Java objects returned from a method (without the MATLAB wrapping), use `unwrapJavaObjectRefs`.

This method recursively connects a single `MWJavaObjectRef` or a multidimensional array of `MWJavaObjectRef` objects to a reference or array of references.

The following code snippets show two examples of calling `unwrapJavaObjectRefs`:

#### Returning a Single Reference or Reference to an Array of Objects with `unwrapJavaObjectRefs`

```
        Hashtable<String,Integer> myHash =
            new Hashtable<String,Integer>();
myHash.put("a", new Integer(3));
myHash.put("b", new Integer(5));
MWJavaObjectRef A =
    new MWJavaObjectRef(new Integer(12));
System.out.println("A referenced the object: "
    + MWJavaObjectRef.unwrapJavaObjectRefs(A));

MWJavaObjectRef B = new MWJavaObjectRef(myHash);
Object bObj = (Object)B;
System.out.println("B referenced the object: "
    + MWJavaObjectRef.unwrapJavaObjectRefs(bObj))
```

Produces the following output:

```
A referenced the object: 12
B referenced the object: {b=5, a=3}
```

#### Returning an Array of References with `unwrapJavaObjectRefs`

```
MWJavaObjectRef A =
    new MWJavaObjectRef(new Integer(12));
MWJavaObjectRef B =
    new MWJavaObjectRef(new Integer(104));
Object[] refArr = new Object[2];
refArr[0] = A;
refArr[1] = B;
Object[] objArr =
    MWJavaObjectRef.unwrapJavaObjectRefs(refArr);
System.out.println("refArr referenced the objects: " +
    objArr[0] + " and " + objArr[1]);
```

Produces the following output:

```
refArr referenced the objects: 12 and 104
```

### **Optimization Example Using `MWJavaObjectRef`**

For a full example of how to use `MWJavaObjectRef` to create a reference to a Java object and pass it to a method, see “Pass Java Objects to MATLAB” on page 5-28.

## Error Handling

### In this section...

“Error Overview” on page 2-30

“Handling Checked Exceptions” on page 2-30

“Handling Unchecked Exceptions” on page 2-33

“Alternatives to Using of System.exit” on page 2-35

### Error Overview

Errors that occur during execution of a MATLAB function or during data conversion are signaled by a standard Java exception. This includes MATLAB run-time errors as well as errors in your MATLAB code.

### Handling Checked Exceptions

Checked exceptions must be declared as thrown by a method using the `throws` clause. MATLAB Compiler SDK Java packages support the `com.mathworks.toolbox.javabuilder` exception `MWException`. This exception class inherits from `java.lang.Exception` and is thrown by every MATLAB Compiler SDK generated Java method to signal that an error has occurred during the call. All normal MATLAB run-time errors, as well as user-created errors (e.g., a calling error in your MATLAB code) are manifested as `MWExceptions`.

The Java interface to each MATLAB function declares itself as throwing an `MWException` using the `throws` clause. For example, the `myprimes` MATLAB function shown previously has the following interface:

```
/* mlx interface – List version */
public void myprimes(List lhs, List rhs) throws MWException
{
    (implementation omitted)
}
/* mlx interface – Array version */
public void myprimes(Object[] lhs, Object[] rhs)
                    throws MWException
{
    (implementation omitted)
}
```

```

    }
    /* Standard interface – no inputs*/
    public Object[] myprimes(int nargout) throws MWException
    {
        (implementation omitted)
    }
    /* Standard interface – one input*/
    public Object[] myprimes(int nargout, Object n)
                                throws MWException
    {
        (implementation omitted)
    }

```

Any method that calls `myprimes` must do one of two things:

- Catch and handle the `MWException`.
- Allow the calling program to catch it.

The following two sections provide examples of each.

### Handling an Exception in the Called Function

The `getprimes` example shown here uses the first of these methods. This method handles the exception itself, and does not need to include a `throws` clause at the start.

```

public double[] getprimes(int n)
{
    myclass cls = null;
    Object[] y = null;

    try
    {
        cls = new myclass();
        y = cls.myprimes(1, new Double((double)n));
        return (double[])((MWArray)y[0]).getData();
    }

    /* Catches the exception thrown by myprimes */
    catch (MWException e)
    {
        System.out.println("Exception: " + e.toString());
        return new double[0];
    }
}

```

```
    finally
    {
        MWArray.disposeArray(y);
        if (cls != null)
            cls.dispose();
    }
}
```

Note that in this case, it is the programmer's responsibility to return something reasonable from the method in case of an error.

The `finally` clause in the example contains code that executes after all other processing in the `try` block is executed. This code executes whether or not an exception occurs or a control flow statement like `return` or `break` is executed. It is common practice to include any cleanup code that must execute before leaving the function in a `finally` block. The documentation examples use `finally` blocks in all the code samples to free native resources that were allocated in the method.

For more information on freeing resources, see “Manage MATLAB Resources” on page 2-36.

### Handling an Exception in the Calling Function

In this next example, the method that calls `myprimes` declares that it throws an `MWException`:

```
public double[] getprimes(int n) throws MWException
{
    myclass cls = null;
    Object[] y = null;

    try
    {
        cls = new myclass();
        y = cls.myprimes(1, new Double((double)n));
        return (double[])((MWArray)y[0]).getData();
    }

    finally
    {
        MWArray.disposeArray(y);
        if (cls != null)
            cls.dispose();
    }
}
```



```
}
```

## Handling Unchecked Exceptions

Several types of unchecked exceptions can also occur during the course of execution. Unchecked exceptions are Java exceptions that do not need to be explicitly declared with a `throws` clause. The `MWArray` API classes all throw unchecked exceptions.

All unchecked exceptions thrown by `MWArray` and its subclasses are subclasses of `java.lang.RuntimeException`. The following exceptions can be thrown by `MWArray`:

- `java.lang.RuntimeException`
- `java.lang.ArrayStoreException`
- `java.lang.NullPointerException`
- `java.lang.IndexOutOfBoundsException`
- `java.lang.NegativeArraySizeException`

This list represents the most likely exceptions. Others might be added in the future.

## Catching General Exceptions

You can easily rewrite the `getprimes` example to catch any exception that can occur during the method call and data conversion. Just change the `catch` clause to catch a general `java.lang.Exception`.

```
public double[] getprimes(int n)
{
    myclass cls = null;
    Object[] y = null;

    try
    {
        cls = new myclass();
        y = cls.myprimes(1, new Double((double)n));
        return (double[])((MWArray)y[0]).getData();
    }

    /* Catches the exception thrown by anyone */
    catch (Exception e)
    {
        System.out.println("Exception: " + e.toString());
    }
}
```

```
        return new double[0];
    }

    finally
    {
        MWArray.disposeArray(y);
        if (cls != null)
            cls.dispose();
    }
}
```

### **Catching Multiple Exception Types**

This second, and more general, variant of this example differentiates between an exception generated in a compiled method call and all other exception types by introducing two `catch` clauses as follows:

```
public double[] getprimes(int n)
{
    myclass cls = null;
    Object[] y = null;

    try
    {
        cls = new myclass();
        y = cls.myprimes(1, new Double((double)n));
        return (double[])((MWArray)y[0]).getData();
    }

    /* Catches the exception thrown by myprimes */
    catch (MWException e)
    {
        System.out.println("Exception in MATLAB call: " +
            e.toString());
        return new double[0];
    }

    /* Catches all other exceptions */
    catch (Exception e)
    {
        System.out.println("Exception: " + e.toString());
        return new double[0];
    }

    finally
```

```
{
    MArray.disposeArray(y);
    if (cls != null)
        cls.dispose();
}
```

The order of the `catch` clauses here is important. Because `MWException` is a subclass of `Exception`, the `catch` clause for `MWException` must occur before the `catch` clause for `Exception`. If the order is reversed, the `MWException` `catch` clause will never execute.

## Alternatives to Using of `System.exit`

Any Java application that uses a class generated using MATLAB Compiler SDK should avoid any direct or indirect calls to `System.exit`.

Any direct or indirect call to `System.exit` will result in the JVM shutting down in an abnormal fashion. This may result in system deadlocks.

Using `System.exit` also causes the `java` process to exit unpredictably.

Java programs using Swing components are most likely to invoke `System.exit`. Here are a few ways to avoid it:

- Use public interface `WindowConstants.DISPOSE_ON_CLOSE` method as an alternative to `WindowConstants.EXIT_ON_CLOSE` as input to the `JFrame` class `setDefaultCloseOperation` method.
- If you want to provide an **Exit** button in your GUI that terminates your application, instead of calling `System.exit` in the `ActionListener` for the button, call the `dispose` method on `JFrame`.

# Manage MATLAB Resources

### In this section...

“Why MATLAB Resources Need to be Managed” on page 2-36

“Creating MATLAB Objects” on page 2-36

“Disposing of MATLAB Objects” on page 2-37

## Why MATLAB Resources Need to be Managed

MATLAB Compiler SDK uses a Java Native Interface (JNI) wrapper connecting your Java application to the C++ MATLAB Runtime. As a result, most of the resources consumed by the MATLAB Compiler SDK portions of your Java application are created by the MATLAB Runtime. Resource created by the MATLAB Runtime are not visible to the JVM. The JVM's garbage collector cannot effectively manage resources that it cannot see.

All of the MATLAB Compiler SDK Java classes have hooks that free the MATLAB resources when the JVM garbage collects the wrapper objects. However, the JVM's garbage collection is unreliable because the JVM only sees the small wrapper object. The garbage collector can decide that it is not worth wasting CPU cycles to actually delete the wrapper object. Until the Java wrapper object is deleted, the resources allocated in the MATLAB Runtime are also not deleted. This behavior can result in conditions that look like memory leaks and rapidly consume resources.

To avoid this situation:

- Never create anonymous MATLAB objects.
- Always dispose of MATLAB objects using their `dispose()` method.

## Creating MATLAB Objects

All of the MATLAB objects supported by MATLAB Compiler SDK have standard Java constructors as described in the `com.mathworks.toolbox.javabuilder` Javadoc.

When creating MATLAB objects, **always** assign them names. To create a 5x5 cell array:

```
MWCellArray myCA = new MWCellArray(5, 5);
```

The Java object `myCA` is a wrapper that points to a `5x5 mxArray` object in the MATLAB Runtime. `myCA` can be added to other MATLAB arrays or manipulated in your Java application. When you are finished with `myCA`, you can clean up the `5x5 mxArray` using the object's `dispose()` method.

The semantics of the API allows you create anonymous MATLAB objects and store them in named MATLAB objects, but you should **never** do this in practice. You have **no way** to manage the MATLAB resources created by the anonymous MATLAB object.

The following code creates a MATLAB array, data, and populates it with an anonymous MATLAB object:

```
MWStructArray data = new MWStructArray(1, KMAX, FIELDS);  
data.set(FIELDS[0], k + 1, new MWNumericArray(k * 1.13));
```

Two MATLAB objects are created. Both objects have a Java wrapper and an MATLAB array object in the MATLAB Runtime. When you dispose of `data`, all of the resources for it are cleaned up. However, the anonymous object created by `new MWNumericArray(k * 1.13)` is just marked for deletion by the JVM. However, because the Java wrapper consumes a tiny amount of space, the garbage collector is likely to leave it around. Because the JVM never cleans up the wrapper object, the MATLAB Runtime never cleans up the resources it has allocated.

The MATLAB object's `set()` methods accept native Java types:

```
MWStructArray data = new MWStructArray(1, KMAX, FIELDS);  
data.set(FIELDS[0], k + 1, k * 1.13);
```

In this instance, only one MATLAB object is created. When its `dispose()` method is called all of the resources are cleaned up.

## Disposing of MATLAB Objects

There are two ways of cleaning up MATLAB objects:

- the object's `dispose()` method
- the static `MWArray.disposeArray()` method

Both methods release all of the resources associated with the MATLAB object. The Java wrapper object is deleted. If there are no other references to the MATLAB Runtime `mxArray` object, it is also deleted.

The following code disposes of a MATLAB object using its `dispose()` method.

```
MWCellArray myCA = new MWCellArray(5, 5);  
...  
myCA.dispose();
```

The following code disposes of a MATLAB object using the `MWArray.disposeArray()` method.

```
MWCellArray myCA = new MWCellArray(5, 5);  
...  
MWArray.disposeArray(myCA);
```

## The MATLAB Runtime User Data Interface

This feature provides a lightweight interface for accessing MATLAB Runtime data. It allows data to be shared between a MATLAB Runtime instance, the MATLAB code running on that MATLAB Runtime, and the wrapper code that created the runtime. Through calls to the MATLAB Runtime User Data interface API, you access MATLAB Runtime data through creation of a per-runtime-instance associative array of `mxArrays`, consisting of a mapping from string keys to `mxArray` values. Reasons for doing this include, but are not limited to:

- You need to supply run-time information to a client running an application created with the Parallel Computing Toolbox. Profile information may be supplied on a per-execution basis. For example, two instances of the same application may run simultaneously with different profiles.
- You want to initialize the MATLAB Runtime with constant values that can be accessed by all your MATLAB applications
- You want to set up a global workspace — a global variable or variables that MATLAB and your client can access
- You want to store the state of any variable or group of variables

MATLAB Compiler SDK software supports per-runtime instance state access through an object-oriented API. Access to a per-runtime instance state is optional, rather than on by default. You can access this state by adding `setmcruserdata.m` and `getmcruserdata.m` to your deployment project or by specifying them on the command line. Alternatively, you use a helper function to call these methods as demonstrated in “Supply Run-Time Profile Information for Parallel Computing Toolbox Applications” on page 2-40.

For more information, see “The MATLAB Runtime User Data Interface”

## Supply Run-Time Profile Information for Parallel Computing Toolbox Applications

Following is a complete example of how you can use the MATLAB Runtime User Data Interface as a mechanism to specify a profile for Parallel Computing Toolbox applications.

### Step 1: Write Your Parallel Computing Toolbox Code

- 1 Compile `sample_pct.m` in MATLAB.

This example code uses the cluster defined in the default profile.

The output assumes that the default profile is `local`.

```
function speedup = sample_pct (n)
warning off all;
tic
if(ischar(n))
    n=str2double(n);
end
for ii = 1:n
    (cov(sin(magic(n)+rand(n,n))));
end
time1 =toc;
parpool;
tic
parfor ii = 1:n
    (cov(sin(magic(n)+rand(n,n))));
end
time2 =toc;
disp(['Normal loop times: ' num2str(time1) ...
    ',parallel loop time: ' num2str(time2) ]);
disp(['parallel speedup: ' num2str(1/(time2/time1)) ...
    ' times faster than normal']);
delete(gcf);
disp('done');
speedup = (time1/time2);
```

- 2 Run the code as follows after changing the default profile to `local`, if needed.

```
a = sample_pct(200)
```



- 3 Verify that you get the following results;

```
Starting matlabpool using the 'local'
      profile ... connected to 4 labs.
Normal loop times: 1.4625, parallel loop time: 0.82891
parallel speedup: 1.7643 times faster than normal
Sending a stop signal to all the labs ... stopped.
done
a =
    1.7643
```

## Step 2: Set the Parallel Computing Toolbox Profile

In order to compile MATLAB code to a Java package and utilize the Parallel Computing Toolbox, the `mcruserdata` must be set directly from MATLAB. There is no Java API available to access the `MCRUserdata` as there is for C and C++ applications built with MATLAB Compiler SDK.

To set the `mcruserdata` from MATLAB, create an `init` function in your Java class. This is a separate MATLAB function that uses `setmcruserdata` to set the Parallel Computing Toolbox™ profile once. You then call your other functions to utilize the Parallel Computing Toolbox functions.

Create the following `init` function:

```
function init_sample_pct
% Set the Parallel Profile:
if(isdeployed)
    [profile, profpath] = uigetfile('*.settings');
    % let the USER select file
    setmcruserdata('ParallelProfile', fullfile(profpath, profile));
end
```

---

**Tip** If you need to change your profile in the application, use the `parallel.importProfile` and `parallel.defaultClusterProfile` methods. See the Parallel Computing Toolbox documentation for more information.

---

## Step 3: Compile Your Function with the Library Compiler App or the Command Line Compiler

You can compile your function from the command line by entering the following:

```
mcc -S -W 'java:parallelComponent,PctClass' init_sample_pct.m sample_pct.m
```

Alternately, you can use the Library Compiler app by following the steps in “Compile Java Packages with Library Compiler App”.

Project Name	parallelComponent
Class Name	PctClass
File to Compile	pct_sample.m and init_pct_sample.m

When the compilation finishes, a new folder with the same name as the project is created. This folder contains the following subfolders:

- for\_redistribution
- for\_redistribution\_files\_only
- for\_testing

---

**Note:** If you are using the GPU feature of Parallel Computing Toolbox, you need to manually add the PTX and CU files.

If you are using the Library Compiler app, click **Add files/directories** on the **Build** tab.

If you are using the `mcc` command, use the `-a` option.

---

### Step 4: Write the Java Driver Application

Write the following Java driver application to use the generated package, as follows, using a Java-compatible IDE such as Eclipse™:

```
import com.mathworks.toolbox.javabuilder.*;
import parallelComponent.*;

public class JavaParallelClass
{
    public static void main(String[] args)
    {
        mxArray A = null;
        PctClass C = null;
        Object[] B = null;
        try
```

```

    {
        C = new PctClass();
        /* Set up the runtime with Parallel Data */
        C.init_sample_pct();
        A = new MWNumericArray(200);
        B = C.sample_pct(1, A);
        System.out.println(" The Speed Up was:" + B[0]);
    }
    catch (Exception e)
    {
        System.out.println("The error is " + e.toString());
    }
    finally
    {
        MWArray.disposeArray(A);
        C.dispose();
    }
}
}

```

The output is as follows:

```

(UIGETFILE brings up the window to select the MAT file)
Starting matlabpool using the 'profile' cluster profile
    ... connected to 4 labs.
Normal loop times: 2.6641, parallel loop time: 1.2568
parallel speedup:  2.1198 times faster than normal
Sending a stop signal to all the labs ... stopped.
Did not find any pre-existing parallel jobs created
    by matlabpool.
done
The Speed Up was:2.1198

```

### Compiling and Running the Application Without Using an IDE

If you are not using an IDE, compile the application using command-line Java, as follows:

---

**Note:** Enter these commands on a single line, using the semi-colon as a delimiter.

---

```

javac -classpath .;C:\pct_compile\javaApp\parallelComponent.jar;
    matlabroot\toolbox\javabuilder\jar\javabuilder.jar JavaParallelClass.java

```

Run the application from the command-line, as follows:

```
java -classpath .;C:\pct_compile\javaApp\parallelComponent.jar;  
      matlabroot/toolbox/javabuilder/jar/javabuilder.jar JavaParallelClass
```

## Dynamically Specify Options to the MATLAB Runtime

### In this section...

“What Options Can You Specify?” on page 2-45

“Setting and Retrieving MATLAB Runtime Option Values Using MWApplication” on page 2-45

### What Options Can You Specify?

You can pass MATLAB Runtime options `-nojvm`, `-nodisplay`, and `-logfile` to MATLAB Compiler SDK from the client application using two classes in `javabuilder.jar`:

- `MWApplication`
- `MWMCROption`

### Setting and Retrieving MATLAB Runtime Option Values Using MWApplication

The `MWApplication` class provides several static methods to set MATLAB Runtime option values and also to retrieve them. The following table lists static methods supported by this class.

<b>MWApplication Static Methods</b>	<b>Purpose</b>
<code>MWApplication.initialize(MWMCROption... options);</code>	Passes runtime options (see “Specifying Run-Time Options Using MWMCROption” on page 2-46)
<code>MWApplication.isMCRInitialized();</code>	Returns <code>true</code> if the runtime is initialized; otherwise returns <code>false</code>
<code>MWApplication.isMCRJVMEEnabled();</code>	Returns <code>true</code> if the runtime is launched with JVM; otherwise returns <code>false</code>
<code>MWApplication.isMCRNoDisplaySet();</code>	Returns <code>true</code> if <code>MWMCROption.NODISPLAY</code>

MWApplication Static Methods	Purpose
	is used in <code>MWApplication.initialize</code>  <b>Note:</b> <code>false</code> is always returned on Windows systems since the <code>-nodisplay</code> option is not supported on Windows systems.
<code>MWApplication.getMCRLogfileName();</code>	Retrieves the name of the log file

### Specifying Run-Time Options Using `MWMCROption`

`MWApplication.initialize` takes zero or more `MWMCROptions`.

Calling `MWApplication.initialize()` without any inputs launches the MATLAB Runtime with the following default values.

You must call `MWApplication.initialize()` before performing any other processing.

These options are all write-once, read-only properties.

MATLAB Runtime Run-Time Option	Default Values
<code>-nojvm</code>	<code>false</code>
<code>-logfile</code>	<code>null</code>
<code>-nodisplay</code>	<code>false</code>

---

**Note:** If there are no MATLAB Runtime options being passed, you do not need to use `MWApplication.initialize` since initializing a generated class initializes the MATLAB Runtime with default options.

---

Use the following static members of `MWMCROption` to represent the MATLAB Runtime options you want to modify.

MWMCROption Static Members	Purpose
<code>MWMCROption.NOJVM</code>	Launches the MATLAB Runtime without a JVM. When this option is used, the JVM launched by the

<b>MWMCROption Static Members</b>	<b>Purpose</b>
	client application is unaffected. The value of this option determines whether or not the runtime should attach itself to the JVM launched by the client application.
MWMCROption.NODISPLAY	Launches the runtime without display functionality.
MWMCROption.logFile("logfile.dat")	Allows you to specify a log file name (must be passed with a log file name).

### Passing and Retrieving MATLAB Runtime Option Values from a Java Application

Following is an example of how MATLAB Runtime option values are passed and retrieved from a client-side Java application:

```
MWApplication.initialize(MWMCROption.NOJVM,
    MWMCROption.logFile("logfile.dat"),MWMCROption.NODISPLAY);
System.out.println(MWApplication.getMCRLogfileName());
System.out.println(MWApplication.isMCRInitialized());
System.out.println(MWApplication.isMCRJVMEabled());
System.out.println(MWApplication.isMCRNoDisplaySet()); //UNIX

myclass cls = new myclass();
cls.hello();
```

## Data Conversion Between Java and MATLAB

In this section...
“Overview” on page 2-48
“Call MWArray Methods” on page 2-48
“Create Buffered Images from a MATLAB Array” on page 2-49

### Overview

The call signature for a method that encapsulates a MATLAB function uses one of the MATLAB data conversion classes to pass arguments and return output. When you call any such method, all input arguments not derived from one of the `MWArray` classes are converted by the compiler to the correct `MWArray` type before being passed to the MATLAB method.

For example, consider the following Java statement:

```
result = theFourier.plotfft(3, data, new Double(interval));
```

The third argument is of type `java.lang.Double`, which converts to a MATLAB 1-by-1 double array.

### Call MWArray Methods

The conversion rules apply not only when calling your own methods, but also when calling constructors and factory methods belonging to the `MWArray` classes. For example, the following code calls the constructor for the `MWNumericArray` class with a Java `double` input. The MATLAB Compiler SDK product converts the Java `double` input to an instance of `MWNumericArray` having a `ClassID` property of `MWClassID.DOUBLE`. This is the equivalent of a MATLAB 1-by-1 `double` array.

```
double Adata = 24;  
MWNumericArray A = new MWNumericArray(Adata);  
System.out.println("Array A is of type " + A.classID());
```

When you run this example, the results are as follows:

```
Array A is of type double
```



### Specifying the Type

To specify the MATLAB to Java type conversion, you supply a specific data type in the constructor. The MATLAB Compiler SDK product converts to the specified type rather than following the default conversion rules.

The following code specifies that *A* should be constructed as a MATLAB 1-by-1 16-bit integer array:

```
double Adata = 24;  
MWNumericArray A = new MWNumericArray(Adata, MWClassID.INT16);
```

### Create Buffered Images from a MATLAB Array

Use the `renderArrayData` method to:

- Create a buffered image from data in a given MATLAB array.
- Verify the array is of three dimensions (height, width, and color component).
- Verify the color component order is red, green, and blue.

Search on `renderArrayData` in the Javadoc for information on input parameters, return values, exceptions thrown, and examples. The Javadoc is located at *matlabroot/help/javabuilder/MWArrayAPI*.

## Set Java Properties

<b>In this section...</b>
---------------------------

“How to Set Java System Properties” on page 2-50
--

“Ensure a Consistent GUI Appearance” on page 2-50
---

### How to Set Java System Properties

Set Java system properties in one of two ways:

- *In the Java statement.* Use the syntax: `java -Dpropertyname=value`, where *propertyname* is the name of the Java system property you want to set and *value* is the value to which you want the property set.
- *In the Java code.* Insert the following statement in your Java code near the top of the `main` function, before you initialize any Java classes:

```
System.setProperty(key, value)
```

*key* is the name of the Java system property you want to set, and *value* is the value to which you want the property set.

### Ensure a Consistent GUI Appearance

After developing your initial GUI using the MATLAB Compiler SDK product, subsequent GUIs that you develop may inherit properties of the MATLAB GUI, rather than properties of your initial design. To preserve your original look and feel, set the `mathworks.DisableSetLookAndFeel` Java system property to `true`.

#### Setting DisableSetLookAndFeel

The following are examples of how to set `mathworks.DisableSetLookAndFeel` using the techniques in “How to Set Java System Properties” on page 2-50:

- In the `java` statement:

```
java -classpath X:/mypath/tomy/javabuilder.jar -  
Dmathworks.DisableSetLookAndFeel=true
```

- In the Java code:

```
Class A {
```

```
main () {  
    System.getProperties().set("mathworks.DisableSetLookAndFeel", "true");  
    foo f = newFoo();  
    }  
}
```

## Block Execution of Applications that Creates Figures

The following example illustrates using `waitForFigures` from a Java application. The example uses a Java class created by the MATLAB Compiler SDK product; the object encapsulates MATLAB code that draws a simple plot.

- 1 Create a work folder for your source code. In this example, the folder is `D:\work\plotdemo`.
- 2 In this folder, create the following MATLAB file:

```
drawplot.m

function drawplot()
    plot(1:10);
```

- 3 Use the compiler to create a Java package with the following properties:

Package name	examples
Class name	Plotter

- 4 Create a Java program in a file named `runplot.java` with the following code:

```
import com.mathworks.toolbox.javabuilder.*;
import examples.Plotter;

public class runplot
{
    public static void main(String[] args)
    {
        try
        {
            plotter p = new Plotter();
            try
            {
                p.showPlot();
                p.waitForFigures();
            }
            finally
            {
                p.dispose();
            }
        }
        catch (MWException e)
        {
```

```
        e.printStackTrace();
    }
}
```

- 5 Compile the application with the `javac` command.

When you run the application, the program displays a plot from 1 to 10 in a MATLAB figure window. The application ends when you dismiss the figure.

---

**Note:** To see what happens without the call to `waitForFigures`, comment out the call, rebuild the application, and run it. In this case, the figure is drawn and is immediately destroyed as the application exits.

---

# Ensure Multi-Platform Portability

Compiled MATLAB code containing only MATLAB files are platform independent, as are `.jar` files. These files can be used out of the box on any platform providing that the platform has either MATLAB or the MATLAB Runtime installed.

However, if your compiled MATLAB code contains MEX-files, which are platform dependent, do the following:

- 1 Compile your MEX-file once on each platform where you want to run your application.

For example, if you are running on a Windows machine, and you want to also run on the Linux 64-bit platform, compile `my_mex.c` twice (once on a PC to get `my_mex.mexw32` and then again on a Linux 64-bit machine to get `my_mex.mexa64`).

- 2 Compile the package on one platform using the `mcc` command, using the `-a` flag to include the MEX-file compiled on the other platform(s). In the example above, run `mcc` on Windows and include the `-a` flag to include `my_mex.mexa64`. In this example, the `mcc` command would be:

```
mcc -W 'java:mycomp,myclass' my_matlab_file.m -a my_mex.mexa64
```

---

**Note:** In this example, it is not necessary to explicitly include `my_mex.mexw32` (providing you are running on Windows). This example assumes that `my_mex.mexw32` and `my_mex.mexa64` reside in the same folder.

---

For example, if you are running on a Windows machine and you want to ensure portability of the generated package that invokes the `yprimes.c` file (from `matlabroot\extern\examples\mex`) on the Linux 64-bit platform, execute the following `mcc` command:

```
mcc -W 'java:mycomp,myclass' callyprime.m -a yprime.mexa64
```

where `callyprime.m` can be a simple MATLAB function as follows:

```
function callyprime
disp(yprime(1,1:4));
```

Ensure the `yprime.mexa64` file is in the same folder as your Windows MEX-file.

---

**Tip** If you are unsure if your JAR file contains MEX-files, do the following:

- 1 Run `mcc` with the `-v` option to list the names of the MEX-files.
  - 2 Obtain appropriate versions of these files from the version of MATLAB installed on your target operating system.
  - 3 Include these versions in the archive by running `mcc` with the `-a` option.
- 

**Caution** Some toolbox functionality will not be deployable when compiled into a Java package and run on a platform other than the one compiled on. This is because some toolbox code includes data that may be platform specific. If this is the case, you can only deploy the application to like platforms. For example, the Image Processing Toolbox function `IMHIST` will fail if deployed cross-platform with an `undefined function error`.

---

JAR files produced by MATLAB Compiler SDK are tested and qualified to run on platforms supported by MATLAB. See the Platform Roadmap for MATLAB for more information.

## Deployable Archive Embedding and Extraction

<b>In this section...</b>
“Overview” on page 2-56
“Use MWComponentOptions Class to Indicate Extraction Options” on page 2-56
“Use Environment Variables to Indicate Extraction Options” on page 2-58
“For More Information” on page 2-59

### Overview

Deployable archive data is extracted from the JAR file with no separate deployable archive or *packageName* folder needed on the target machine. This behavior is helpful when storage space on a file system is limited.

If you don't want deployable archive data extracted by default, use either the `MWComponentOptions` class, or use environment variables, to specify how deployable archive data extraction and utilization is handled.

### Use MWComponentOptions Class to Indicate Extraction Options

#### Selecting Options

Choose from the following `CtfSource` or `ExtractLocation` instantiation options to customize how to manage deployable archive content with `MWComponentOptions`:

- `CtfSource` — This option specifies where the deployable archive may be found for an extracted component. It defines a binary data stream comprised of the bits of the deployable archive. The following values are objects of some type extending `MWCtfSource`:
  - `MWCtfSource.NONE` — Indicates that no deployable archive is to be extracted. This implies that the extracted deployable archive data is already accessible somewhere on your file system. This is a public, static, final instance of `MWCtfSource`.
  - `MWCtfFileSource` — Indicates that the deployable archive data resides within a particular file location that you specify. This class takes a `java.io.File` object in its constructor.



- `MWCtfDirectorySource` — Indicates a folder to be scanned when instantiating the component: if a file with a `.ctf` suffix is found in the folder you supply, the deployable archive bits are loaded from that file. This class takes a `java.io.File` object in its constructor.
- `MWCtfStreamSource` — Allows deployable archive bits to be read and extracted directly from a specified input stream. This class takes a `java.io.InputStream` object in its constructor.
- `ExtractLocation` — This option specifies where the extracted deployable archive content is to be located. Since the MATLAB Runtime requires all deployable archive content be located somewhere on your file system, use the desired `ExtractLocation` option, along with the component type information, to define a unique location. A value for this option is an instance of the class `MWCtfExtractLocation`. An instance of this class can be created by passing a `java.io.File` or `java.lang.String` into the constructor to specify the file system location to be used or one of these predefined, static final instances may be used:
  - `MWCtfExtractLocation.EXTRACT_TO_CACHE` — Use to indicate that the deployable archive content is to be placed in the MATLAB Runtime component cache. This is the default setting for R2007a and forward.
  - `MWCtfExtractLocation.EXTRACT_TO_COMPONENT_DIR` — Use when you want to locate the JAR or `.class` files from which the component has been loaded. If the location is found (e.g., it is on the file system), then the deployable archive data is extracted into the same folder. This option most closely matches the behavior of R2007a and previous releases.

---

**Note:** Deployable archives are extracted by default to `temp\user_name\mcrCache.nn`.

---

### Setting Options

Use the following methods to get or set the location where the deployable archive may be found for an extracted component:

- `getCtfSource()`
- `setCtfSource()`

Use the following methods to get or set the location where the extracted deployable archive content is to be located:

- `getExtractLocation()`
- `setExtractLocation()`

### Enabling MATLAB Runtime Component Cache, Utilizing Deployable Archive Content Already on Your System

If you want to enable the MATLAB Runtime Component Cache for a generated Java class utilizing deployable archive content already resident in your file system, instantiate `MWComponentOptions` using the following statements:

```
MWComponentOptions options = new MWComponentOptions();

// set options for the class by calling setter methods
// on 'options'
options.setCtfSource(MWCtfSource.NONE);
options.setExtractLocation(
    new MWCtfExtractLocation("C:\\readonlydir\\MyModel_mcr"));

// instantiate the class using the desired options
MyModel m = new MyModel(options);
```

### Use Environment Variables to Indicate Extraction Options

Use the following environment variables to change these settings.

Environment Variable	Purpose	Notes
<code>MCR_CACHE_ROOT</code>	When set to the location of where you want the deployable archive to be extracted, this variable overrides the default per-user component cache location.	Does not apply
<code>MCR_CACHE_VERBOSE</code>	When set to any value, this variable prints logging details about the component cache for diagnostic reasons. This can be very helpful if problems are encountered during deployable archive extraction.	Logging details are turned off by default (for example, when this variable has no value).

Environment Variable	Purpose	Notes
MCR_CACHE_SIZE	When set, this variable overrides the default component cache size.	The initial limit for this variable is 32M (megabytes). This may, however, be changed after you have set the variable the first time. Edit the file <code>.max_size</code> , which resides in the file designated by running the <code>mcrcachedir</code> command, with the desired cache size limit.

### Overriding Default Behavior

To extract the deployable archive, compile using the `-C` option when calling `mcc`.

You can also implement this override by entering `-C` in the **Settings** editor of the Library Compiler app.

You might want to use this option to troubleshoot problems with the deployable archive, for example, as the log and diagnostic messages are much more visible.

### For More Information

For more information about the deployable archive, see “Deployable Archive”.

### Explore the Javadoc

The Javadoc can be browsed from *matlabroot/help/javabuilder/MWArrayAPI* in your product installation and by entering the name of the class or method you want to learn more about in the search field on the **Index** page.

Javadoc contains, among other information:

- Signatures that diagram method and class usage
- Parameters passed in, return values expected, and exceptions that can be thrown
- Examples demonstrating typical usage of the class or method

# Distribute Integrated Java Applications

---

- “Package Java Applications” on page 3-2
- “About the MATLAB Runtime” on page 3-3
- “Download the MATLAB Runtime Installer” on page 3-5
- “Install the MATLAB Runtime” on page 3-6
- “MATLAB and MATLAB Runtime on Same Machine” on page 3-10
- “Multiple MATLAB Runtime on Single Machine” on page 3-11
- “Uninstall MATLAB Runtime” on page 3-12

## Package Java Applications

**1** Gather and package the following files for installation on end user computers:

- MATLAB Runtime installer

See “Download the MATLAB Runtime Installer” on page 3-5.

- MATLAB generated Java package
- JAR files for the application

**2** Include directions for installing the MATLAB Runtime.

See “Install the MATLAB Runtime” on page 3-6.

**3** Include directions for adding the required JAR files to the Java CLASSPATH.

At a minimum, the CLASSPATH must include:

- `mcrroot/toolbox/javabuilder/jar/javabuilder.jar`
- MATLAB generated Java package
- JAR files for the application

## About the MATLAB Runtime

### In this section...

“How is the MATLAB Runtime Different from MATLAB?” on page 3-3

“Performance Considerations and the MATLAB Runtime” on page 3-4

The MATLAB Runtime is a standalone set of shared libraries, MATLAB code, and other files that enables the execution of MATLAB files on computers without an installed version of MATLAB. Applications that use artifacts built with MATLAB Compiler SDK require access to an appropriate version of the MATLAB Runtime to run.

End-users of compiled artifacts without access to MATLAB must install the MATLAB Runtime on their computers or know the location of a network-installed MATLAB Runtime. The installers generated by the compiler apps may include the MATLAB Runtime installer. If you compiled your artifact using `mcc`, you should direct your end-users to download the MATLAB Runtime installer from the website <http://www.mathworks.com/products/compiler/mcr>.

See “Install the MATLAB Runtime” on page 3-6 for more information.

### How is the MATLAB Runtime Different from MATLAB?

The MATLAB Runtime differs from MATLAB in several important ways:

- In the MATLAB Runtime, MATLAB files are encrypted and immutable.
- MATLAB has a desktop graphical interface. The MATLAB Runtime has all the MATLAB functionality without the graphical interface.
- The MATLAB Runtime is version-specific. You must run your applications with the version of the MATLAB Runtime associated with the version of MATLAB Compiler SDK with which it was created. For example, if you compiled an application using version 4.10 (R2009a) of MATLAB Compiler, users who do not have MATLAB installed must have version 7.10 of the MATLAB Runtime installed. Use `mcrversion` to return the version number of the MATLAB Runtime.
- The MATLAB paths in an MATLAB Runtime instance are fixed and cannot be changed. To change them, you must first customize them within MATLAB.

### **Performance Considerations and the MATLAB Runtime**

MATLAB Compiler SDK was designed to work with a large range of applications that use the MATLAB programming language. Because of this, run-time libraries are large.

Since the MATLAB Runtime technology provides full support for the MATLAB language, including the Java programming language, starting a compiled application takes approximately the same amount of time as starting MATLAB. The amount of resources consumed by the MATLAB Runtime is necessary in order to retain the power and functionality of a full version of MATLAB.

Calls into the MATLAB Runtime are serialized so calls into the MATLAB Runtime are threadsafe. This can impact performance.



## Download the MATLAB Runtime Installer

Download the MATLAB Runtime from the website at <http://www.mathworks.com/products/compiler/mcr>.

## Install the MATLAB Runtime

**In this section...**

“Install the MATLAB Runtime Interactively” on page 3-6

“Install the MATLAB Runtime Non-Interactively” on page 3-7

### Install the MATLAB Runtime Interactively

To install the MATLAB Runtime:

- 1 Start the MATLAB Runtime installer.

Computer	Steps
Windows	Double-click the compiled MATLAB code package self-extracting archive file, typically named <i>my_program_pkg.exe</i> , where <i>my_program</i> is the name of the MATLAB code. This extracts the MATLAB Runtime installer from the archive, along with all the files that make up the MATLAB Runtime. Once all the files have been extracted, the MATLAB Runtime installer starts automatically.
Linux Mac	<p>Extract the contents of the compiled package, which is a Zip file on Linux systems, typically named, <i>my_program_pkg.zip</i>, where <i>my_program</i> is the name of the compiled MATLAB code. Use the <code>unzip</code> command to extract the files from the package.</p> <pre>unzip MCRInstaller.zip</pre> <p>Run the MATLAB Runtime installer script, from the directory where you unzipped the package file, by entering:</p> <pre>./install</pre> <p>For example, if you unzipped the package and MATLAB Runtime installer in <code>\home\USER</code>, you run the <code>./install</code> from <code>\home\USER</code>.</p> <hr/> <p><b>Note:</b> On Mac systems, you may need to enter an administrator username and password after you run <code>./install</code>.</p>

- 2 When the MATLAB Runtime installer starts, it displays a dialog box. Read the information and then click **Next** to proceed with the installation.
- 3 Specify the folder in which you want to install the MATLAB Runtime in the **Folder Selection** dialog box.

---

**Note:** On Windows systems, you can have multiple versions of the MATLAB Runtime on your computer but only one installation for any particular version. If you already have an existing installation, the MATLAB Runtime installer does not display the **Folder Selection** dialog box because you can only overwrite the existing installation in the same folder.

---

- 4 Confirm your choices and click **Next**.

The MATLAB Runtime installer starts copying files into the installation folder.

- 5 On Linux and Mac systems, after copying files to your disk, the MATLAB Runtime installer displays the **Product Configuration Notes** dialog box. This dialog box contains information necessary for setting your path environment variables. Copy the path information from this dialog box and then click **Next**.
- 6 Click **Finish** to exit the installer.

## Install the MATLAB Runtime Non-Interactively

To install the MATLAB Runtime without having to interact with the installer dialog boxes, use one of the MATLAB Runtime installer's non-interactive modes:

- **silent**—the installer runs as a background task and does not display any dialog boxes
- **automated**—the installer displays the dialog boxes but does not wait for user interaction

When run in silent or automated mode, the MATLAB Runtime installer uses default values for installation options. You can override these defaults by using MATLAB Runtime installer command-line options or an installer control file.

---

**Note:** When running in silent or automated mode, the installer overwrites the default installation location.

---

### Running the Installer in Silent Mode

To install the MATLAB Runtime in silent mode:

- 1 Extract the contents of the MATLAB Runtime installer file to a temporary folder, called `$temp` in this documentation.

---

**Note:** On Windows systems, **manually** extract the contents of the installer file.

---

- 2 Run the MATLAB Runtime installer, specifying the `-mode` option and `-agreeToLicense yes` on the command line.

---

**Note:** On most platforms, the installer is located at the root of the folder into which the archive was extracted. On Windows 64, the installer is located in the `archives bin` folder.

---

Platform	Command
Windows	<code>setup -mode silent -agreeToLicense yes</code>
Linux	<code>./install -mode silent -agreeToLicense yes</code>
Mac OS X	<code>./install -mode silent -agreeToLicense yes</code>

---

**Note:** If you do not include the `-agreeToLicense yes` the installer will not install the MATLAB Runtime.

---

- 3 View a log of the installation.

On Windows systems, the MATLAB Runtime installer creates a log file, named `mathworks_username.log`, where `username` is your Windows log-in name, in the location defined by your `TEMP` environment variable.

On Linux and Mac systems, the MATLAB Runtime installer displays the log information at the command prompt, unless you redirect it to a file.

#### Customizing a Non-Interactive Installation

When run in one of the non-interactive modes, the installer will use the default values unless told to do otherwise. Like the MATLAB installer, the MATLAB Runtime installer accepts a number of command line options that modify the default installation properties.

---

Option	Description
-destinationFolder	Specifies where the MATLAB Runtime will be installed.
-outputFile	Specifies where the installation log file is written.
-automatedModeTimeout	Specifies how long, in milliseconds, that the dialog boxes are displayed when run in automatic mode.
-inputFile	Specifies an installer control file with the values for all of the above options.

---

**Note:** The MATLAB Runtime installer archive includes an example installer control file called `installer_input.txt`. This file contains all of the options available for a full MATLAB installation. Only the options listed in this section are valid for the MATLAB Runtime installer.

---

## MATLAB and MATLAB Runtime on Same Machine

You do not need to install MATLAB Runtime on your machine if your machine has both MATLAB and MATLAB Compiler SDK installed. The version of MATLAB should be the same as the version of MATLAB that was used to create the compiled MATLAB code.

You can, however, install the MATLAB Runtime for debugging purposes.

### Modifying the Path

If you install MATLAB Runtime on a machine that already has MATLAB on it, you must adjust the library path according to your needs.

- **Windows**

To run deployed MATLAB code against MATLAB Runtime install, `mcr_root\ver\runtime\win32|win64` must appear on your system path before `matlabroot\runtime\win32|win64`.

If `mcr_root\ver\runtime\arch` appears first on the compiled application path, the application uses the files in the MATLAB Runtime install area.

If `matlabroot\runtime\arch` appears first on the compiled application path, the application uses the files in the MATLAB installation area.

- **UNIX**

To run deployed MATLAB code against MATLAB Runtime on Linux, Linux x86-64, or the `<mcr_root>/runtime/<arch>` folder must appear on your `LD_LIBRARY_PATH` before `matlabroot/runtime/<arch>`.

To run deployed MATLAB code on Mac OS X, the `<mcr_root>/runtime` folder must appear on your `DYLD_LIBRARY_PATH` before `matlabroot/runtime/<arch>`.

To run MATLAB on Mac OS X or Intel® Mac, `matlabroot/runtime/<arch>` must appear on your `DYLD_LIBRARY_PATH` before the `<mcr_root>/bin` folder.

## Multiple MATLAB Runtime on Single Machine

MCRInstaller supports the installation of multiple versions of the MATLAB Runtime on a target machine. This allows applications compiled with different versions of the MATLAB Runtime to execute side by side on the same machine.

If you do not want multiple MATLAB Runtime versions on the target machine, you can remove the unwanted ones. On Windows, run **Add or Remove Programs** from the Control Panel to remove any of the previous versions. On UNIX, you manually delete the unwanted MATLAB Runtime. You can remove unwanted versions before or after installation of a more recent version of the MATLAB Runtime, as versions can be installed or removed in any order.

# Uninstall MATLAB Runtime

The method you use to uninstall MATLAB Runtime from your computer varies depending on the type of computer.

## Windows

- 1 Start the uninstaller.

From the Windows Start menu, search for the **Add or Remove Programs** control panel, and double-click MATLAB Runtime in the list.

You can also launch the MATLAB Runtime uninstaller from the *mcr\_root*\uninstall\bin\*arch* folder, where *mcr\_root* is your MATLAB Runtime installation folder and *arch* is an architecture-specific folder, such as win64.

- 2 Select the MATLAB Runtime from the list of products in the Uninstall Products dialog box and
- 3 Click **Next**.
- 4 Click **Finish**.

## Linux

- 1 Exit the application.
- 2 Enter this command at the Linux prompt:

```
rm -rf mcr_root
```

where *mcr\_root* represents the name of your top-level MATLAB installation folder.

## Mac

- Exit the application.
- Navigate to your MATLAB Runtime installation folder. For example, the installation folder might be named `MATLAB_Compiler_Runtime.app` in your Applications folder.
- Drag your MATLAB Runtime installation folder to the trash, and then select **Empty Trash** from the Finder menu.



# Distribute to End Users

---

- “MATLAB Runtime Path Settings for Development and Testing” on page 4-2
- “MATLAB Runtime Path Settings for Run-Time Deployment” on page 4-4

## MATLAB Runtime Path Settings for Development and Testing

<b>In this section...</b>
---------------------------

“Path for Java Development on All Platforms ” on page 4-2
---

“Path Modifications Required for Accessibility” on page 4-2
---

“Windows Settings for Development and Testing” on page 4-2
--

“Linux Settings for Development and Testing” on page 4-2
--

“OS X Settings for Development and Testing” on page 4-3
---

### Path for Java Development on All Platforms

There are additional requirements when programming in the Java programming language. For more information see “Configure Your Java Environment”.

### Path Modifications Required for Accessibility

In order to use some screen-readers or assistive technologies, such as JAWS<sup>®</sup>, you must add the following DLLs to your Windows path:

```
matlabroot\sys\java\jre\arch\jre\bin\JavaAccessBridge.dll
```

```
matlabroot\sys\java\jre\arch\jre\bin\WindowsAccessBridge.dll
```

You may not be able to use such technologies without doing so.

### Windows Settings for Development and Testing

When programming with compiled MATLAB code, add the following folder to your system PATH environment variable:

```
matlabroot\runtime\win32|win64
```

### Linux Settings for Development and Testing

Add the following platform-specific folders to your dynamic library path.

---

**Note** For readability, the following commands appear on separate lines, but you must enter each `setenv` command on one line.

---

```
setenv LD_LIBRARY_PATH
  matlabroot/runtime/glnxa64:
  matlabroot/bin/glnxa64:
  matlabroot/sys/os/glnxa64:
  matlabroot/sys/opengl/lib/glnxa64
```

## OS X Settings for Development and Testing

Add the following platform-specific folders to your dynamic library path.

---

**Note** For readability, the following commands appear on separate lines, but you must enter each `setenv` command on one line.

---

```
setenv DYLD_LIBRARY_PATH
  matlabroot/runtime/maci64:
  matlabroot/bin/maci64:
  matlabroot/sys/os/maci64:
```

## MATLAB Runtime Path Settings for Run-Time Deployment

### In this section...

“General Path Guidelines” on page 4-4

“Path for Java Applications on All Platforms” on page 4-4

“Windows Path for Run-Time Deployment” on page 4-4

“Linux Paths for Run-Time Deployment” on page 4-5

“OS X Paths for Run-Time Deployment” on page 4-5

### General Path Guidelines

Regardless of platform, be aware of the following guidelines with regards to placing specific folders on the path:

- Always avoid including `bin` or `arch` on the path. Failure to do so may inhibit ability to run multiple MATLAB Runtime instances.
- Ideally, set the environment in a separate shell script to avoid run-time errors caused by path-related issues.

### Path for Java Applications on All Platforms

When your users run applications that contain compiled MATLAB code, you must instruct them to set the path so that the system can find the MATLAB Runtime.

---

**Note:** When you deploy a Java application to end users, they must set the class path on the target machine.

The system needs to find `.jar` files containing the MATLAB libraries. To tell the system how to locate the `.jar` files it needs, specify a `classpath` either in the `javac` command or in your system environment variables.

---

### Windows Path for Run-Time Deployment

The following folder should be added to the system path:

`mcr_root\version\runtime\win32|win64`

*mcr\_root* refers to the complete path where the MATLAB Runtime library archive files are installed on the machine where the application is to be run.

*mcr\_root* is version specific; you must determine the path after you install the MATLAB Runtime.

---

**Note:** If you are running the MATLAB Runtime installer on a shared folder, be aware that other users of the share may need to alter their system configuration.

---

## Linux Paths for Run-Time Deployment

Use these `setenv` commands to set your MATLAB Runtime paths.

```
setenv LD_LIBRARY_PATH
  mcr_root/version/runtime/glnxa64:
  mcr_root/version/bin/glnxa64:
  mcr_root/version/sys/os/glnxa64:
  mcr_root/version/sys/opengl/lib/glnxa64
```

## OS X Paths for Run-Time Deployment

Use these `setenv` commands to set your MATLAB Runtime paths.

```
setenv DYLD_LIBRARY_PATH
  mcr_root/version/runtime/maci64:
  mcr_root/version/bin/maci64:
  mcr_root/version/sys/os/maci64
```



# Sample Java Applications

---

- “Display a MATLAB Plot in a Java Application” on page 5-2
- “Create a Java Application with Two MATLAB Functions” on page 5-7
- “Matrix Math” on page 5-13
- “Phone Book” on page 5-22
- “Pass Java Objects to MATLAB” on page 5-28
- “Display a MATLAB Plot in a Web Application” on page 5-37

---

**Note:** Remember to double-quote all parts of the `java` command paths that contain spaces. To test directly against the MATLAB Runtime when executing `java`, substitute *mcrroot* for *matlabroot*, where *mcrroot* is the location where the MATLAB Runtime is installed on your system.

---

## Display a MATLAB Plot in a Java Application

### In this section...

“Purpose” on page 5-2

“Procedure” on page 5-2

### Purpose

The purpose of the example is to show you how to do the following:

- Use the MATLAB Compiler SDK product to convert a MATLAB function (`drawplot.m`) to a method of a Java class (`plotter`) and wrap the class in a Java package (`plotdemo`).
- Access the MATLAB function in a Java application (`createplot.java`) by instantiating the `plotter` class and using the `MWArray` class library to handle data conversion.

---

**Note:** For complete reference information about the `MWArray` class hierarchy, see the `com.mathworks.toolbox.javabuilder` package.

---

- Build and run the `createplot.java` application.

The `drawplot.m` function displays a plot of input parameters `x` and `y`.

### Procedure

- 1 If you have not already done so, copy the files for this example as follows:
  - a Copy the following folder that ships with MATLAB to your work folder:  
`matlabroot\toolbox\javabuilder\Examples\PlotExample`
  - b At the MATLAB command prompt, `cd` to the new `PlotExample` subfolder in your work folder.
- 2 If you have not already done so, set the environment variables that are required on a development machine. See “Configure Your Java Environment” on page 1-3.
- 3 Write the `drawplot.m` function as you would any MATLAB function.

The following code defines the `drawplot.m` function:

```
function drawplot(x,y)
```



```
plot(x,y);
```

This code is already in your work folder in `PlotExample\PlotDemoComp\drawplot.m`.

- 4 While in MATLAB, issue the following command to open the Library Compiler app:

```
libraryCompiler
```

- 5 You create a Java package by using the Library Compiler app to build a Java class that wraps around your MATLAB code.

To create the Java package the Library Compiler app, use the following information as you work through this example in “Compile Java Packages with Library Compiler App”:

Project Name	plotdemo
Class Name	plotter
File to compile	drawplot.m

- 6 Write source code for an application that accesses the MATLAB function.

The sample application for this example is in `matlabroot\toolbox\javabuilder\Examples\PlotExample\PlotDemoJavaApp\createplot.java`.

The program graphs a simple parabola from the equation  $y = x^2$ .

The program listing is shown here.

### **createplot.java**

```
/* Necessary package imports */
import com.mathworks.toolbox.javabuilder.*;
import plotdemo.*;

/*
 * createplot class demonstrates plotting x-y data into
 * a MATLAB figure window by graphing a simple parabola.
 */
class createplot
{
    public static void main(String[] args)
    {
        MWNumericArray x = null; /* Array of x values */
        MWNumericArray y = null; /* Array of y values */
        plotter thePlot = null; /* Plotter class instance */
        int n = 20; /* Number of points to plot */

        try
        {
```

```
/* Allocate arrays for x and y values */
int[] dims = {1, n};
x = MWNumericArray.newInstance(dims,
    MWClassID.DOUBLE, MWComplexity.REAL);
y = MWNumericArray.newInstance(dims,
    MWClassID.DOUBLE, MWComplexity.REAL);

/* Set values so that y = x^2 */
for (int i = 1; i <= n; i++)
{
    x.set(i, i);
    y.set(i, i*i);
}

/* Create new plotter object */
thePlot = new plotter();

/* Plot data */
thePlot.drawplot(x, y);
thePlot.waitForFigures();
}

catch (Exception e)
{
    System.out.println("Exception: " + e.toString());
}

finally
{
    /* Free native resources */
    MWArray.disposeArray(x);
    MWArray.disposeArray(y);
    if (thePlot != null)
        thePlot.dispose();
}
}
```

The program does the following:

- Creates two arrays of double values, using `MWNumericArray` to represent the data needed to plot the equation.
- Instantiates the `plotter` class as `thePlot` object, as shown:

```
thePlot = new plotter();
```

- Calls the `drawplot` method to plot the equation using the MATLAB `plot` function, as shown:

```
thePlot.drawplot(x,y);
```

- Uses a `try-catch` block to catch and handle any exceptions.

- 7 Compile the `createplot` application using `javac`. When entering this command, ensure there are no spaces between path names in the `matlabroot` argument. For example, there should be no space between `javabuilder.jar`; and .

`\distrib\plotdemo.jar` in the following example. `cd` to your work folder. Ensure `createplot.java` is in your work folder

- On Windows, execute this command:

```
javac -classpath
    .;matlabroot\toolbox\javabuilder\jar\javabuilder.jar;
    .\distrib\plotdemo.jar createplot.java
```

- On UNIX, execute this command:

```
javac -classpath
    .:matlabroot/toolbox/javabuilder/jar/javabuilder.jar:
    ./distrib/plotdemo.jar createplot.java
```

- 8** Run the application.

To run the `createplot.class` file, do one of the following:

- On Windows, type:

```
java -classpath
    .;matlabroot\toolbox\javabuilder\jar\javabuilder.jar;
    .\distrib\plotdemo.jar
    createplot
```

- On UNIX, type:

```
java -classpath
    .:matlabroot/toolbox/javabuilder/jar/javabuilder.jar:
    ./distrib/plotdemo.jar
    createplot
```

---

**Note:** You should be using the same version of Java that ships with MATLAB. To find out what version of Java MATLAB is running, enter the following MATLAB command:

```
version -java
```

---

**Caution** MathWorks only supports the Oracle JDK and JRE. A certain measure of cross-version compatibility resides in the Oracle software and it *may* be

---

---

possible to run applications with compiled MATLAB functions with non-Oracle

---

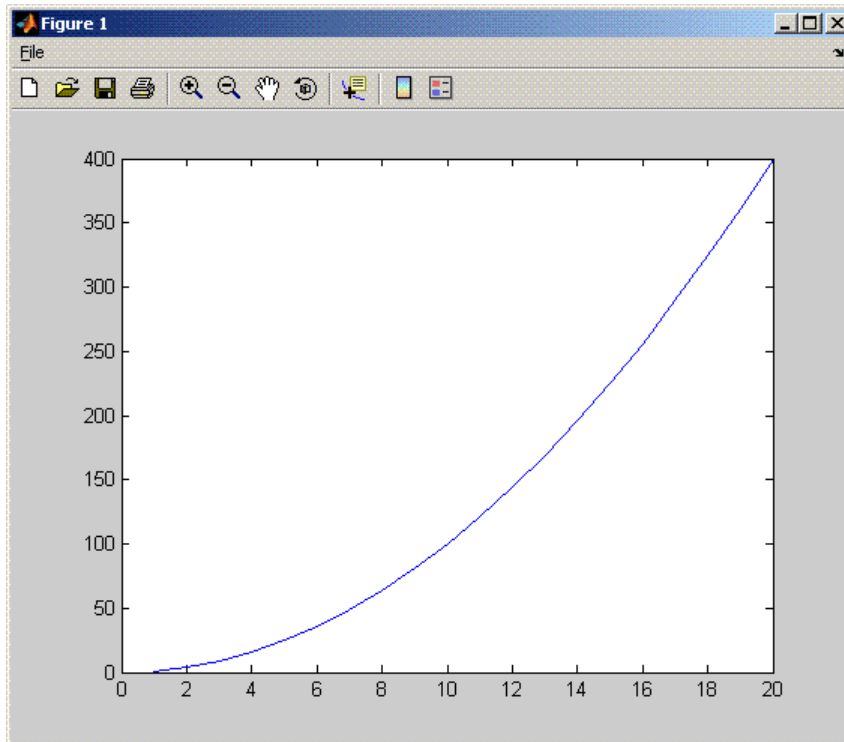
JDKs under some circumstances—however, compatibility is not guaranteed.

---

**Note:** If you are running on the Mac 64-bit platform, you must add the `-d64` flag in the Java command. See “Limitations of the MATLAB Compiler SDK Java Target” on page 10-3 for more specific information.

---

The `createplot` program should display the output.



## Create a Java Application with Two MATLAB Functions

### In this section...

“Purpose” on page 5-7

“Procedure” on page 5-7

### Purpose

The purpose of the example is to show you the following:

- How to use the MATLAB Compiler SDK product to create a package containing a class that has a private method that is automatically encapsulated.
- How to access the MATLAB functions in a Java application, including use of the `MWArray` class hierarchy to represent data

---

**Note:** For complete reference information about the `MWArray` class hierarchy, see the `com.mathworks.toolbox.javabuilder` package.

---

- How to build and run the application

The `spectralanalysis` package analyzes a signal and graphs the result. The class, `fourier`, performs a fast Fourier transform (FFT) on an input data array. A method of this class, `computefft`, returns the results of that FFT as two output arrays—an array of frequency points and the power spectral density. The second method, `plotfft`, graphs the returned data. These two methods, `computefft` and `plotfft`, encapsulate MATLAB functions.

The MATLAB code for these two methods is in `computefft.m` and `plotfft.m`, which is found in `matlabroot\toolbox\javabuilder\Examples\SpectraExample\SpectraDemoComp`.

### Procedure

- 1 If you have not already done so, copy the files for this example as follows:
  - a Copy the following folder that ships with MATLAB to your work folder:  
`matlabroot\toolbox\javabuilder\Examples\SpectraExample`
  - b At the MATLAB command prompt, `cd` to the new `SpectraExample` subfolder in your work folder.

- 2 If you have not already done so, set the environment variables that are required on a development machine. See “Configure Your Java Environment” on page 1-3.
- 3 Write the MATLAB code that you want to access.

This example uses `computefft.m` and `plotfft.m` which are already in your work folder in `SpectraExample\SpectraDemoComp`.

- 4 Open the Library Compiler app.
- 5 Create the Java package by using the Library Compiler app to build a Java class that wraps your MATLAB code.

Use the following information as you work through this example in “Compile Java Packages with Library Compiler App”:

Project Name	<code>spectralanalysis</code>
Class Name	<code>fourier</code>
File to compile	<code>plotfft.m</code>

---

**Note:** In this example, the application that uses the `fourier` class does not need to call `computefft` directly. The `computefft` method is required only by the `plotfft` method. Thus, when creating the package, you do not need to add the `computefft` function, although doing so does no harm.

---

- 6 Write source code for an application that accesses the MATLAB functions.

The sample application for this example is in `SpectraExample\SpectraDemoJavaApp\powerspect.java`.

The program listing is shown here.

### **powerspect.java**

```
/* Necessary package imports */
import com.mathworks.toolbox.javabuilder.*;
import spectralanalysis.*;

/*
 * powerspect class computes and plots the power
 * spectral density of an input signal.
 */
class powerspect
{
    public static void main(String[] args)
    {
        double interval = 0.01; /* Sampling interval */
        int nSamples = 1001; /* Number of samples */
    }
}
```

```

MWNumericArray data = null; /* Stores input data */
Object[] result = null; /* Stores result */
fourier theFourier = null; /* Fourier class instance */

try
{
    /*
    * Construct input data as sin(2*PI*15*t) +
    * sin(2*PI*40*t) plus a random signal.
    * Duration = 10
    * Sampling interval = 0.01
    */
    int[] dims = {1, nSamples};
    data = MWNumericArray.newInstance(dims, MWClassID.DOUBLE,
                                     MWComplexity.REAL);
    for (int i = 1; i <= nSamples; i++)
    {
        double t = (i-1)*interval;
        double x = Math.sin(2.0*Math.PI*15.0*t) +
            Math.sin(2.0*Math.PI*40.0*t) +
            Math.random();
        data.set(i, x);
    }

    /* Create new fourier object */
    theFourier = new fourier();
    theFourier.waitForFigures();

    /* Compute power spectral density and plot result */
    result = theFourier.plotfft(3, data,
                               new Double(interval));
}

catch (Exception e)
{
    System.out.println("Exception: " + e.toString());
}

finally
{
    /* Free native resources */
    MWArray.disposeArray(data);
    MWArray.disposeArray(result);
    if (theFourier != null)
        theFourier.dispose();
}
}
}

```

The program does the following:

- Constructs an input array with values representing a random signal with two sinusoids at 15 and 40 Hz embedded inside of it
- Creates an `MWNumericArray` array that contains the data, as shown:

```
data = MWNumericArray.newInstance(dims, MWClassID.DOUBLE, MWComplexity.REAL);
```
- Instantiates a `fourier` object

- Calls the `plotfft` method, which calls `computefft` and plots the data
  - Uses a `try-catch` block to handle exceptions
  - Frees native resources using `MWArray` methods
- 7 Compile the `powerspect.java` application using `javac`. When entering this command, ensure there are no spaces between path names in the *matlabroot* argument. For example, there should be no space between `javabuilder.jar`; and `.\distrib\spectralanalysis.jar` in the following example.

Open a Command Prompt window and `cd` to the *matlabroot*\spectralanalysis folder. `cd` to your work folder. Ensure `powerspect.java` is in your work folder

- On Windows, execute the following command:

```
javac -classpath
.;matlabroot\toolbox\javabuilder\jar\javabuilder.jar;
.\distrib\spectralanalysis.jar powerspect.java
```

- On UNIX, execute the following command:

```
javac -classpath
.:matlabroot/toolbox/javabuilder/jar/javabuilder.jar:
./distrib/spectralanalysis.jar powerspect.java
```

---

**Note:** For *matlabroot* substitute the root MATLAB folder on your system. Type `matlabroot` to see this folder name.

---

- 8 Run the application.

- On Windows, execute the `powerspect` class file:

```
java -classpath
.;matlabroot\toolbox\javabuilder\jar\javabuilder.jar
.\distrib\spectralanalysis.jar
powerspect
```

- On UNIX, execute the `powerspect` class file:

```
java -classpath
.:matlabroot/toolbox/javabuilder/jar/javabuilder.jar:
./distrib/spectralanalysis.jar
powerspect
```



**Note:** You should be using the same version of Java that ships with MATLAB. To find out what version of Java MATLAB is running, enter the following MATLAB command:

```
version -java
```

---

**Caution** MathWorks only supports the Oracle JDK and JRE. A certain measure

---

of cross-version compatibility resides in the Oracle software and it *may* be possible to run applications with compiled MATLAB functions with non-Oracle JDKs under some circumstances—however, compatibility is not guaranteed.

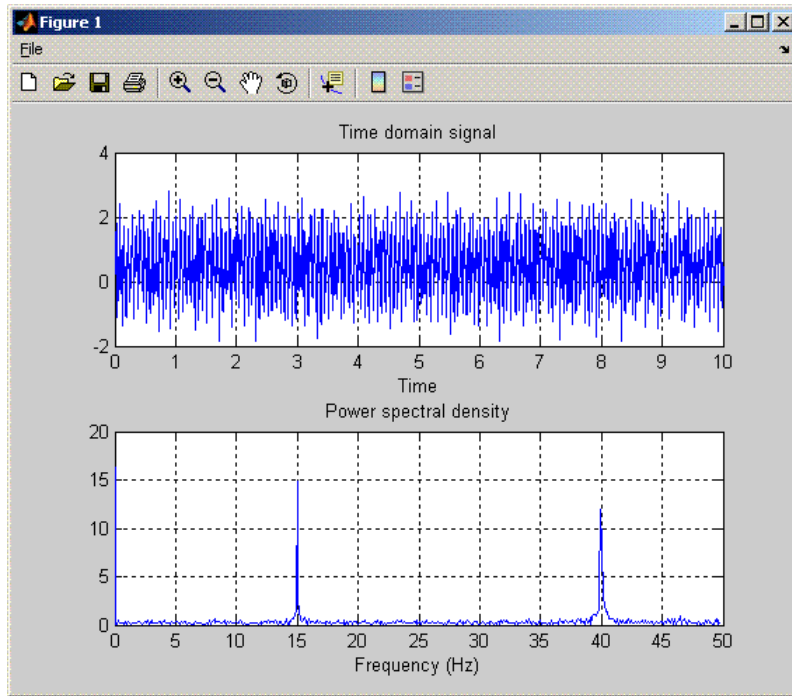
---

---

**Note:** If you are running on the Mac 64-bit platform, you must add the `-d64` flag in the Java command. See “Limitations of the MATLAB Compiler SDK Java Target” on page 10-3 for more specific information.

---

The `powerspect` program should display the output:



# Matrix Math

## In this section...

“Purpose” on page 5-13

“MATLAB Functions to Be Encapsulated” on page 5-14

“Understanding the getfactor Program” on page 5-14

“Procedure” on page 5-14

## Purpose

The purpose of the example is to show you the following:

- How to assign more than one MATLAB function to a generated class.
- How to manually handle native memory management.
- How to access the MATLAB functions in a Java application (`getfactor.java`) by instantiating `Factor` and using the `MWArray` class library to handle data conversion.

---

**Note:** For complete reference information about the `MWArray` class hierarchy, see the `com.mathworks.toolbox.javabuilder` package.

---

- How to build and run the `MatrixMathDemoApp` application

This example builds a Java package to perform matrix math. The example creates a program that performs Cholesky, LU, and QR factorizations on a simple tridiagonal matrix (finite difference matrix) with the following form:

$$A = \begin{bmatrix} 2 & -1 & 0 & 0 & 0 \\ -1 & 2 & -1 & 0 & 0 \\ 0 & -1 & 2 & -1 & 0 \\ 0 & 0 & -1 & 2 & -1 \\ 0 & 0 & 0 & -1 & 2 \end{bmatrix}$$

You supply the size of the matrix on the command line, and the program constructs the matrix and performs the three factorizations. The original matrix and the results are printed to standard output. You may optionally perform the calculations using a sparse matrix by specifying the string "sparse" as the second parameter on the command line.

## MATLAB Functions to Be Encapsulated

The following code defines the MATLAB functions used in the example:

- `cholesky.m`

```
function [L] = cholesky(A)
L = chol(A);
```
- `ludcomp.m`

```
function [L,U] = ludcomp(A)
[L,U] = lu(A);
```
- `qrdecomp.m`

```
function [Q,R] = qrdecomp(A)
[Q,R] = qr(A);
```

## Understanding the `gefactor` Program

The `gefactor` program takes one or two arguments from standard input. The first argument is converted to the integer order of the test matrix. If the string `sparse` is passed as the second argument, a sparse matrix is created to contain the test array. The Cholesky, LU, and QR factorizations are then computed and the results are displayed to standard output.

The main method has three parts:

- The first part sets up the input matrix, creates a new factor object, and calls the `cholesky`, `ludcomp`, and `qrdecomp` methods. This part is executed inside of a `try` block. This is done so that if an exception occurs during execution, the corresponding `catch` block will be executed.
- The second part is the `catch` block. The code prints a message to standard output to let the user know about the error that has occurred.
- The third part is a `finally` block to manually clean up native resources before exiting.

## Procedure

### Procedure 5.3. Step-by-Step Procedure

- 1 If you have not already done so, copy the files for this example as follows:

- a Copy the following folder that ships with MATLAB to your work folder:
 

```
matlabroot\toolbox\javabuilder\Examples\MatrixMathExample
```
- b At the MATLAB command prompt, `cd` to the new `MatrixMathExample` subfolder in your work folder.
- 2 If you have not already done so, set the environment variables that are required on a development machine. See “Configure Your Java Environment” on page 1-3.
- 3 Write the MATLAB functions as you would any MATLAB function.

The code for `cholesky.m`, `ludecomp.m`, and `qrdecomp.m` functions is already in your work folder in `MatrixMathExample\MatrixMathDemoComp\`.

- 4 Select Library Compiler app.
- 5 Create the Java package using the Library Compiler app to build a Java class that wraps around your MATLAB code.

Use the following information as you work through this example in “Compile Java Packages with Library Compiler App”:

Project Name	factormatrix
Class Name	factor
Files to compile	cholesky.m, ludecomp.m, and qrdecomp.m

- 6 Write source code for an application that accesses the MATLAB functions.

The sample application for this example is in `MatrixMathExample\MatrixMathDemoJavaApp\getfactor.java`.

The program listing is shown here.

### **getfactor.java**

```
/* Necessary package imports */
import com.mathworks.toolbox.javabuilder.*;
import factormatrix.*;

/*
 * getfactor class computes cholesky, LU, and QR
 * factorizations of a finite difference matrix
 * of order N. The value of N is passed on the
 * command line. If a second command line arg
 * is passed with the value of "sparse", then
 * a sparse matrix is used.
 */
class getfactor
```

```

{
public static void main(String[] args)
{
    MWNumericArray a = null;    /* Stores matrix to factor */
    Object[] result = null;    /* Stores the result */
    factor theFactor = null;    /* Stores factor class instance */

    try
    {
        /* If no input, exit */
        if (args.length == 0)
        {
            System.out.println("Error: must input a positive integer");
            return;
        }

        /* Convert input value */
        int n = Integer.valueOf(args[0]).intValue();

        if (n <= 0)
        {
            System.out.println("Error: must input a positive integer");
            return;
        }

        /*
         * Allocate matrix. If second input is "sparse"
         * allocate a sparse array
         */
        int[] dims = {n, n};

        if (args.length > 1 && args[1].equals("sparse"))
            a = MWNumericArray.newSparse(dims[0], dims[1], n+2*(n-1),
                                         MWClassID.DOUBLE, MWComplexity.REAL);
        else
            a = MWNumericArray.newInstance(dims, MWClassID.DOUBLE, MWComplexity.REAL);

        /* Set matrix values */
        int[] index = {1, 1};

        for (index[0] = 1; index[0] <= dims[0]; index[0]++)
        {
            for (index[1] = 1; index[1] <= dims[1]; index[1]++)
            {
                if (index[1] == index[0])
                    a.set(index, 2.0);
                else if (index[1] == index[0]+1 || index[1] == index[0]-1)
                    a.set(index, -1.0);
            }
        }

        /* Create new factor object */
        theFactor = new factor();

        /* Print original matrix */
        System.out.println("Original matrix:");
        System.out.println(a);

        /* Compute cholesky factorization and print results. */
        result = theFactor.cholesky(1, a);
        System.out.println("Cholesky factorization:");
        System.out.println(result[0]);
    }
}

```

```

MMArray.disposeArray(result);

/* Compute LU factorization and print results. */
result = theFactor.ludecomp(2, a);
System.out.println("LU factorization:");
System.out.println("L matrix:");
System.out.println(result[0]);
System.out.println("U matrix:");
System.out.println(result[1]);
MMArray.disposeArray(result);

/* Compute QR factorization and print results. */
result = theFactor.qrdecomp(2, a);
System.out.println("QR factorization:");
System.out.println("Q matrix:");
System.out.println(result[0]);
System.out.println("R matrix:");
System.out.println(result[1]);
}

catch (Exception e)
{
    System.out.println("Exception: " + e.toString());
}

finally
{
    /* Free native resources */
    MMArray.disposeArray(a);
    MMArray.disposeArray(result);
    if (theFactor != null)
        theFactor.dispose();
}
}
}

```

The statement:

```
theFactor = new factor();
```

creates an instance of the class `factor`.

The following statements call the methods that encapsulate the MATLAB functions:

```

result = theFactor.cholesky(1, a);
...
result = theFactor.ludecomp(2, a);
...
result = theFactor.qrdecomp(2, a);
...

```

- 7** Copy `getfactor.java` into the `factormatrix` folder.
- 8** Compile the `getfactor` application using `javac`. When entering this command, ensure there are no spaces between path names in the `matlabroot` argument. For

example, there should be no space between `javabuilder.jar`; and `.\distrib\factormatrix.jar` in the following example.

`cd` to the `factormatrix` folder in your work folder.

- On Windows, execute the following command:

```
javac -classpath
.;matlabroot\toolbox\javabuilder\jar\javabuilder.jar;
.\distrib\factormatrix.jar getfactor.java
```

- On UNIX, execute the following command:

```
javac -classpath
.:matlabroot/toolbox/javabuilder/jar/javabuilder.jar:
./distrib/factormatrix.jar getfactor.java
```

- 9 Run the application.

Run `getfactor` using a nonsparse matrix

- On Windows, execute the `getfactor` class file as follows:

```
java -classpath
.;matlabroot\toolbox\javabuilder\jar\javabuilder.jar;
.\distrib\factormatrix.jar
getfactor 4
```

- On UNIX, execute the `getfactor` class file as follows:

```
java -classpath
.:matlabroot/toolbox/javabuilder/jar/javabuilder.jar:
./distrib/factormatrix.jar
getfactor 4
```

---

**Note:** You should be using the same version of Java that ships with MATLAB. To find out what version of Java MATLAB is running, enter the following MATLAB command:

```
version -java
```

---

**Caution** MathWorks only supports the Oracle JDK and JRE. A certain measure of cross-version compatibility resides in the Oracle software and it *may* be possible to

---



---

run applications with compiled MATLAB functions with non-Oracle JDKs under some

---

circumstances—however, compatibility is not guaranteed.

---

**Note:** If you are running on the Mac 64-bit platform, you must add the `-d64` flag in the Java command. See “Limitations of the MATLAB Compiler SDK Java Target” on page 10-3 for more specific information.

---

### Output for the Matrix Math Example

Original matrix:

2	-1	0	0
-1	2	-1	0
0	-1	2	-1
0	0	-1	2

Cholesky factorization:

1.4142	-0.7071	0	0
0	1.2247	-0.8165	0
0	0	1.1547	-0.8660
0	0	0	1.1180

LU factorization:

L matrix:

1.0000	0	0	0
-0.5000	1.0000	0	0
0	-0.6667	1.0000	0
0	0	-0.7500	1.0000

U matrix:

2.0000	-1.0000	0	0
0	1.5000	-1.0000	0
0	0	1.3333	-1.0000
0	0	0	1.2500

QR factorization:

Q matrix:

-0.8944	-0.3586	-0.1952	0.1826
0.4472	-0.7171	-0.3904	0.3651

```
    0    0.5976   -0.5855    0.5477
    0         0    0.6831    0.7303
```

R matrix:

```
 -2.2361    1.7889   -0.4472         0
    0   -1.6733    1.9124   -0.5976
    0         0   -1.4639    1.9518
    0         0         0    0.9129
```

To run the same program for a sparse matrix, use the same command and add the string `sparse` to the command line:

```
java (... same arguments) getfactor 4 sparse
```

### Output for a Sparse Matrix

Original matrix:

```
(1,1)    2
(2,1)   -1
(1,2)   -1
(2,2)    2
(3,2)   -1
(2,3)   -1
(3,3)    2
(4,3)   -1
(3,4)   -1
(4,4)    2
```

Cholesky factorization:

```
(1,1)    1.4142
(1,2)   -0.7071
(2,2)    1.2247
(2,3)   -0.8165
(3,3)    1.1547
(3,4)   -0.8660
(4,4)    1.1180
```

LU factorization:

L matrix:

```
(1,1)    1.0000
(2,1)   -0.5000
(2,2)    1.0000
```

(3,2)	-0.6667
(3,3)	1.0000
(4,3)	-0.7500
(4,4)	1.0000

U matrix:

(1,1)	2.0000
(1,2)	-1.0000
(2,2)	1.5000
(2,3)	-1.0000
(3,3)	1.3333
(3,4)	-1.0000
(4,4)	1.2500

QR factorization:

Q matrix:

(1,1)	0.8944
(2,1)	-0.4472
(1,2)	0.3586
(2,2)	0.7171
(3,2)	-0.5976
(1,3)	0.1952
(2,3)	0.3904
(3,3)	0.5855
(4,3)	-0.6831
(1,4)	0.1826
(2,4)	0.3651
(3,4)	0.5477
(4,4)	0.7303

R matrix:

(1,1)	2.2361
(1,2)	-1.7889
(2,2)	1.6733
(1,3)	0.4472
(2,3)	-1.9124
(3,3)	1.4639
(2,4)	0.5976
(3,4)	-1.9518
(4,4)	0.9129

## Phone Book

In this section...
“Purpose” on page 5-22
“Procedure” on page 5-22

### Purpose

An example of how to process an `MWStructArray` as output from a generated class might be:

```
Object[] tmp = myComponent.myFunction(1, myArray);
MWStructArray myStruct = (MWStructArray) tmp[0];
```

The `makephone` function takes a structure array as an input, modifies it, and supplies the modified array as an output.

---

**Note:** For complete reference information about the `MWArray` class hierarchy, see the `com.mathworks.toolbox.javabuilder` package.

---

### Procedure

- 1 If you have not already done so, copy the files for this example as follows:
  - a Copy the following folder that ships with MATLAB to your work folder:  
`matlabroot\toolbox\javabuilder\Examples\PhoneExample`
  - b At the MATLAB command prompt, `cd` to the new `PhoneExample` subfolder in your work folder.
- 2 If you have not already done so, set the environment variables that are required on a development machine. See “Configure Your Java Environment” on page 1-3.
- 3 Write the `makephone` function as you would any MATLAB function.

The following code defines the `makephone` function:

```
function book = makephone(friends)

book = friends;
for i = 1:numel(friends)
    numberStr = num2str(book(i).phone);
    book(i).external = ['(508) 555-' numberStr];
end
```

- This code is already in your work folder in `makephone.m`.
- 4 Select Library Compiler app.
  - 5 Create a Java Package using the Library Compiler app to build a Java class that wraps around your MATLAB code.

Use the following information as you work through this example in “Compile Java Packages with Library Compiler App”:

Project Name	phonebookdemo
Class Name	phonebook
File to compile	makephone.m

- 6 Write source code for an application that accesses the MATLAB functions.

The sample application for this example is in `matlabroot\toolbox\javabuilder\Examples\PhoneExample\PhoneDemoJavaApp\getphone.java`.

The program defines a structure array containing names and phone numbers, modifies it using a MATLAB function, and displays the resulting structure array.

The program listing is shown here.

### getphone.java

```

/* Necessary package imports */
import com.mathworks.toolbox.javabuilder.*;

import phonebookdemo.*;

/*
 * getphone class demonstrates the use of the MWStructArray class
 */
class getphone
{
    public static void main(String[] args)
    {
        phonebook thePhonebook = null; /* Stores magic class instance */
        MWStructArray friends = null; /* Sample input data */
        Object[] result = null; /* Stores the result */
        MWStructArray book = null; /* Output data extracted from result */

        try
        {
            /* Create new magic object */
            thePhonebook = new phonebook();

            /* Create an MWStructArray with two fields */
            String[] myFieldNames = {"name", "phone"};
            friends = new MWStructArray(2,2,myFieldNames);

```

```

        /* Populate struct with some sample data --- friends and phone numbers */
        friends.set("name",1,new MWCharArray("Jordan Robert"));
        friends.set("phone",1,3386);
        friends.set("name",2,new MWCharArray("Mary Smith"));
        friends.set("phone",2,3912);
        friends.set("name",3,new MWCharArray("Stacy Flora"));
        friends.set("phone",3,3238);
        friends.set("name",4,new MWCharArray("Harry Alpert"));
        friends.set("phone",4,3077);

        /* Show some of the sample data */
        System.out.println("Friends: ");
        System.out.println(friends.toString());

        /* Pass it to a MATLAB function that determines external phone number */
        result = thePhonebook.makephone(1, friends);
        book = (MWStructArray)result[0];
        System.out.println("Result: ");
        System.out.println(book.toString());

        /* Extract some data from the returned structure */
        System.out.println("Result record 2:");
        System.out.println(book.getField("name",2));
        System.out.println(book.getField("phone",2));
        System.out.println(book.getField("external",2));

        /* Print the entire result structure using the helper function below */
        System.out.println("");
        System.out.println("Entire structure:");
        dispStruct(book);
    }
    catch (Exception e)
    {
        System.out.println("Exception: " + e.toString());
    }
    finally
    {
        /* Free native resources */
        MWArray.disposeArray(result);
        MWArray.disposeArray(friends);
        MWArray.disposeArray(book);
        if (thePhonebook != null)
            thePhonebook.dispose();
    }
}

public static void dispStruct(MWStructArray arr) {
    System.out.println("Number of Elements: " + arr.numberofElements());
    //int numDims = arr.numberofDimensions();
    int[] dims = arr.getDimensions();
    System.out.print("Dimensions: " + dims[0]);
    for (int i = 1; i < dims.length; i++)
    {
        System.out.print("-by-" + dims[i]);
    }
    System.out.println("");
    System.out.println("Number of Fields: " + arr.numberofFields());
    System.out.println("Standard MATLAB view:");
    System.out.println(arr.toString());
    System.out.println("Walking structure:");
}

```

```

java.lang.String[] fieldNames = arr.fieldNames();
for (int element = 1; element <= arr.numberOfElements(); element++) {
    System.out.println("Element " + element);
    for (int field = 0; field < arr.numberOfFields(); field++) {
        MWArray fieldVal = arr.getField(fieldNames[field], element);
        /* Recursively print substructures, give string display of other classes */
        if (fieldVal instanceof MWStructArray)
        {
            System.out.println("    " + fieldNames[field] + ": nested structure:");
            System.out.println("    +++ Begin of \"" +
                fieldNames[field] + "\" nested structure");
            dispStruct((MWStructArray)fieldVal);
            System.out.println("    +++ End of \"" + fieldNames[field] +
                "\" nested structure");
        } else {
            System.out.print("    " + fieldNames[field] + ": ");
            System.out.println(fieldVal.toString());
        }
    }
}
}
}
}

```

The program does the following:

- Creates a structure array, using `MWStructArray` to represent the example phonebook data.
  - Instantiates the plotter class as the `thePhonebook` object, as shown: `thePhonebook = new phonebook();`
  - Calls the `makephone` method to create a modified copy of the structure by adding an additional field, as shown: `result = thePhonebook.makephone(1, friends);`
  - Uses a `try-catch` block to catch and handle any exceptions.
- 7** Compile the `getphone` application using `javac`. When entering this command, ensure there are no spaces between path names in the `matlabroot` argument. For example, there should be no space between `javabuilder.jar`; and `.\distrib\phonebookdemo.jar` in the following example. `cd` to your work folder. Ensure `getphone.java` is in your work folder

- On Windows, execute this command:

```

javac -classpath
    .;matlabroot\toolbox\javabuilder\jar\javabuilder.jar;
    .\distrib\phonebookdemo.jar getphone.java

```

- On UNIX, execute this command:

```

javac -classpath
    .:matlabroot/toolbox/javabuilder/jar/javabuilder.jar:

```

- ```
./distrib/phonebookdemo.jar getphone.java
```
- 8 Run the application.

To run the `getphone.class` file, do one of the following:

- On Windows, type:

```
java -classpath
.;matlabroot\toolbox\javabuilder\jar\javabuilder.jar;
.\distrib\phonebookdemo.jar
getphone
```

- On UNIX, type:

```
java -classpath
.:matlabroot/toolbox/javabuilder/jar/javabuilder.jar:
./distrib/phonebookdemo.jar
getphone
```

---

**Note:** You should be using the same version of Java that ships with MATLAB. To find out what version of Java MATLAB is running, enter the following MATLAB command:

```
version -java
```

---

**Caution** MathWorks only supports the Oracle JDK and JRE. A certain measure

---

of cross-version compatibility resides in the Oracle software and it *may* be possible to run applications with compiled MATLAB functions with non-Oracle JDKs under some circumstances—however, compatibility is not guaranteed.

---

---

**Note:** If you are running on the Mac 64-bit platform, you must add the `-d64` flag in the Java command. See “Limitations of the MATLAB Compiler SDK Java Target” on page 10-3 for more specific information.

---

The `getphone` program should display the output:

```
Friends:
2x2 struct array with fields:
```



```
    name
    phone
Result:
2x2 struct array with fields:
    name
    phone
    external
Result record 2:
Mary Smith
3912
(508) 555-3912

Entire structure:
Number of Elements: 4
Dimensions: 2-by-2
Number of Fields: 3
Standard MATLAB view:
2x2 struct array with fields:
    name
    phone
    external
Walking structure:
Element 1
    name: Jordan Robert
    phone: 3386
    external: (508) 555-3386
Element 2
    name: Mary Smith
    phone: 3912
    external: (508) 555-3912
Element 3
    name: Stacy Flora
    phone: 3238
    external: (508) 555-3238
Element 4
    name: Harry Alpert
    phone: 3077
    external: (508) 555-3077
```

## Pass Java Objects to MATLAB

| In this section...               |
|----------------------------------|
| “Purpose” on page 5-28           |
| “OptimDemo Package” on page 5-28 |
| “Procedure” on page 5-29         |

### Purpose

This example shows how to:

- Use the MATLAB Compiler SDK product to create a package that applies MATLAB optimization routines to objective functions implemented as Java objects.
- Access the MATLAB functions in a Java application, including use of the `MWJavaObjectRef` class to create a reference to a Java object and pass it to the generated Java methods.

---

**Note:** For complete reference information about the `MWArray` class hierarchy, see the `com.mathworks.toolbox.javabuilder` Javadoc package in `matlabroot/help/toolbox/javabuilder/MWArrayAPI`.

---

- Build and run the application.

### OptimDemo Package

The `OptimDemo` package finds a local minimum of an objective function and returns the minimal location and value. The package uses the MATLAB optimization function `fminsearch`, and this example optimizes the Rosenbrock banana function used in the `fminsearch` documentation. The class, `Optimizer`, performs an unconstrained nonlinear optimization on an objective function implemented as a Java object. A method of this class, `doOptim`, accepts an initial guess and Java object that implements the objective function, and returns the location and value of a local minimum. The second method, `displayObj`, is a debugging tool that lists the characteristics of a Java object. These two methods, `doOptim` and `displayObj`, encapsulate MATLAB functions. The MATLAB code for these two methods is in `doOptim.m` and `displayObj.m`, which can be found in `matlabroot\toolbox\javabuilder\Examples\ObjectRefExample\ObjectRefDemoComp`.

## Procedure

- 1 If you have not already done so, copy the files for this example as follows:
  - 1 Copy the following folder that ships with MATLAB to your work folder:  
`matlabroot\toolbox\javabuilder\Examples\ObjectRefExample`
  - 2 At the MATLAB command prompt, `cd` to the new `ObjectRefExample` subfolder in your work folder.
- 2 If you have not already done so, set the environment variables that are required on a development machine. See “Configure Your Java Environment” on page 1-3.
- 3 Write the MATLAB code that you want to access. This example uses `doOptim.m` and `displayObj.m`, which are already in your work folder in `ObjectRefExample\ObjectRefDemoComp`.

For reference, the code of `doOptim.m` is displayed here:

```
function [x,fval] = doOptim(h, x0)

% FMINSEARCH can't operate directly on Java
%   objective functions,
% so you must create an anonymous function with the correct
% signature to wrap the Java object.
% Here, we assume our object has a method evaluateFunction()
% that takes an array of doubles and returns a double.
% This could become an Interface,
% and we could check that the object implements that Interface.
mWrapper = @(x) h.evaluateFunction(x);

% Compare two ways of evaluating the objective function
% These eventually call the same Java method, and return the
% same results.
directEval = h.evaluateFunction(x0)
wrapperEval = mWrapper(x0)

[x,fval] = fminsearch(mWrapper,x0)
```

For reference, the code of `displayObj.m` is displayed here:

```
function className = displayObj(h)

h
className = class(h)
whos('h')
methods(h)
```

- 4 Open the Library Compiler app.
- 5 Create a Java package using the Library Compiler app to build a Java class that wraps around your MATLAB code.

Use the following information as you work through this example in “Compile Java Packages with Library Compiler App”:

|                 |                            |
|-----------------|----------------------------|
| Project Name    | OptimDemo                  |
| Class Name      | Optimizer                  |
| File to compile | doOptim.m and displayObj.m |

- 6 Write source code for a class that implements an object function to optimize. The sample application for this example is in `ObjectRefExample\ObjectRefDemoJavaApp\BananaFunction.java`. The program listing is shown here:

```
public class BananaFunction {
    public BananaFunction() {}
    public double evaluateFunction(double[] x)
    {
        /* Implements the Rosenbrock banana function described in
         * the FMINSEARCH documentation
         */
        double term1 = 100*java.lang.Math.pow((x[1]-Math.pow(x[0],2.0)),2.0);
        double term2 = Math.pow((1-x[0]),2.0);
        return term1 + term2;
    }
}
```

The class implements the Rosenbrock banana function described in the `fminsearch` documentation.

- 7 Write source code for an application that accesses the MATLAB functions. The sample application for this example is in `ObjectRefExample\ObjectRefDemoJavaApp\PerformOptim.java`. The program listing is shown here:

```
/* Necessary package imports */
import com.mathworks.toolbox.javabuilder.*;
import OptimDemo.*;

/*
 * Demonstrates the use of the MWJavaObjectRef class
 * Takes initial point for optimization as two arguments:
 *     PerformOptim -1.2 1.0
 */
```

```

class PerformOptim
{
public static void main(String[] args)
{
    Optimizer theOptimizer = null; /* Stores component
                                   instance */
    MWJavaObjectRef origRef = null; /* Java object reference to
                                   be passed to component */
    MWJavaObjectRef outputRef = null; /* Output data extracted
                                       from result */
    MWNumericArray x0 = null; /* Initial point for optimization */
    MWNumericArray x = null; /* Location of minimal value */
    MWNumericArray fval = null; /* Minimal function value */
    Object[] result = null; /* Stores the result */

    try
    {
        /* If no input, exit */
        if (args.length < 2)
        {
            System.out.println("Error: must input initial x0_1
                               and x0_2 position");
            return;
        }

        /* Instantiate a new Java object */
        /* This should only be done once per application instance */
        theOptimizer = new Optimizer();

        try {
            /* Initial point --- parse data from text fields */
            double[] x0Data = new double[2];
            x0Data[0] = Double.valueOf(args[0]).doubleValue();
            x0Data[1] = Double.valueOf(args[1]).doubleValue();
            x0 = new MWNumericArray(x0Data, MWClassID.DOUBLE);
            System.out.println("Using x0 =");
            System.out.println(x0);

            /* Create object reference to objective function object */
            BananaFunction objectiveFunction = new BananaFunction();
            origRef = new MWJavaObjectRef(objectiveFunction);

            /* Pass Java object to a MATLAB function that lists its

```

```
                methods, etc */
System.out.println("*****");
System.out.println("** Properties of Java object **");
System.out.println("*****");
result = theOptimizer.displayObj(1, origRef);
MWArray.disposeArray(result);
System.out.println("** Finished DISPLAYOBJ *****");

/* Call the Java component to optimize the function */
/* using the MATLAB function FMINSEARCH */
System.out.println("*****");
System.out.println("** Unconstrained nonlinear optim**");
System.out.println("*****");
result = theOptimizer.doOptim(2, origRef, x0);
try {
    System.out.println("** Finished DOOPTIM *****");
    x = (MWNumericArray)result[0];
    fval = (MWNumericArray)result[1];

    /* Display the results of the optimization */
    System.out.println("Location of minimum: ");
    System.out.println(x);
    System.out.println("Function value at minimum: ");
    System.out.println(fval.toString());
}
finally
{
    MWArray.disposeArray(result);
}
}
finally
{
    /* Free native resources */
    MWArray.disposeArray(origRef);
    MWArray.disposeArray(outputRef);
    MWArray.disposeArray(x0);
}
}
catch (Exception e)
{
    System.out.println("Exception: " + e.toString());
}

finally
```

```

    {
        /* Free native resources */
        if (theOptimizer != null)
            theOptimizer.dispose();
    }
}
}
}

```

The program does the following:

- Instantiates an object of the `BananaFunction` class above to be optimized.
  - Creates an `MWJavaObjectRef` that references the `BananaFunction` object, as shown: `origRef = new MWJavaObjectRef(objectiveFunction);`
  - Instantiates an `Optimizer` object
  - Calls the `displayObj` method to verify that the Java object is being passed correctly
  - Calls the `doOptim` method, which uses `fminsearch` to find a local minimum of the objective function
  - Uses a `try/catch` block to handle exceptions
  - Frees native resources using `MWArray` methods
- 8** Compile the `PerformOptim.java` application and `BananaFunction.java` helper class using `javac`. When entering this command, ensure there are no spaces between path names in the `matlabroot` argument. For example, there should be no space between `javabuilder.jar`; and `.\distrib\OptimDemo.jar` in the following example.

- 1** Open a Command Prompt window and `cd` to the `matlabroot\ObjectRefExample` folder.
- 2** Compile the application according to which operating system you are running on:

- On Windows, execute this command:

```

javac -classpath
.;matlabroot\toolbox\javabuilder\jar\javabuilder.jar;
.\distrib\OptimDemo.jar BananaFunction.java
javac -classpath
.;matlabroot\toolbox\javabuilder\jar\javabuilder.jar;
.\distrib\OptimDemo.jar PerformOptim.java

```

- On UNIX, execute this command:

```
javac -classpath
.:matlabroot/toolbox/javabuilder/jar/javabuilder.jar:
./distrib/OptimDemo.jar BananaFunction.java
javac -classpath
.:matlabroot/toolbox/javabuilder/jar/javabuilder.jar:
./distrib/OptimDemo.jar PerformOptim.java
```

- 9 Execute the `PerformOptim` class file as follows:

On Windows, type:

```
java -classpath
.;matlabroot\toolbox\javabuilder\jar\javabuilder.jar
.\distrib\OptimDemo.jar
PerformOptim -1.2 1.0
```

On UNIX, type:

```
java -classpath
.:matlabroot/toolbox/javabuilder/jar/javabuilder.jar:
./distrib/OptimDemo.jar
PerformOptim -1.2 1.0
```

---

**Note:** You should be using the same version of Java that ships with MATLAB. To find out what version of Java MATLAB is running, enter the following MATLAB command:

```
version -java
```

---

**Caution** MathWorks only supports the Oracle JDK and JRE. A certain measure

---

of cross-version compatibility resides in the Oracle software and it *may* be possible to run applications with compiled MATLAB functions with non-Oracle JDKs under some circumstances—however, compatibility is not guaranteed.

---

---

**Note:** If you are running on the Mac 64-bit platform, you must add the `-d64` flag in the Java command. See “Limitations of the MATLAB Compiler SDK Java Target” on page 10-3 for more specific information.

---



When run successfully, the PerformOptim program should display the following output:

```

Using x0 =
-1.2000    1.0000
*****
** Properties of Java object          **
*****

h =

BananaFunction@1766806

className =

BananaFunction

      Name      Size      Bytes  Class      Attributes

      h         1x1                BananaFunction

Methods for class BananaFunction:

BananaFunction  getClass      notifyAll
equals          hashCode     toString
evaluateFunction  notify      wait

** Finished DISPLAYOBJ *****
*****
** Performing unconstrained nonlinear optimization **
*****

directEval =

    24.2000

wrapperEval =

    24.2000

```

x =

1.0000 1.0000

fval =

8.1777e-10

Optimization successful

\*\* Finished DOOPTIM \*\*\*\*\*

Location of minimum:

1.0000 1.0000

Function value at minimum:

8.1777e-10

## Display a MATLAB Plot in a Web Application

### In this section...

“Overview” on page 5-37

“Prerequisites” on page 5-37

“Locating the Example Files” on page 5-38

“Build Your Java Package” on page 5-39

“Compiling Your Java Code” on page 5-39

“Generating the Web Archive (WAR) File ” on page 5-40

“Running the Web Deployment Example” on page 5-40

“Using the Web Application” on page 5-41

### Overview

This example demonstrates how to display a plot created by a Java servlet calling a class created with the MATLAB Compiler SDK product over a Web interface. This example uses MATLAB `varargin` and `varargout` for optional input and output to the `varargexample.m` function. For more information about `varargin` and `varargout`, see “Specify Optional Arguments” on page 2-16.

### Prerequisites

This section describes what you need to know and do before you create the Web deployment example.

- “Ensure You Have the Required Products” on page 5-37
- “Ensure Your Web Server Is Java Compliant” on page 5-38
- “Install the `javabuilder.jar` Library” on page 5-38

### Ensure You Have the Required Products

The following products must be installed at their recommended release levels.

**MATLAB, MATLAB Compiler, MATLAB Compiler SDK**

This example was tested with R2007b.

### Java Development Kit (JDK)

Ensure you have a JDK installed on your system. You can download it from Oracle, Inc.

---

**Note:** You should be using the same version of Java that ships with MATLAB. To find out what version of Java MATLAB is running, enter the following MATLAB command:

```
version -java
```

---

**Caution** MathWorks only supports the Oracle JDK and JRE. A certain measure of

---

cross-version compatibility resides in the Oracle software and it *may* be possible to run applications with compiled MATLAB functions with non-Oracle JDKs under some circumstances—however, compatibility is not guaranteed.

---

### Ensure Your Web Server Is Java Compliant

In order to run this example, your Web server must be capable of running accepted Java frameworks like J2EE. Running the WebFigures example (“Implement a Custom WebFigure” on page 6-5) also requires the ability to run servlets in WARs (Web Archives).

### Install the javabuilder.jar Library

Ensure that the `javabuilder.jar` library (`matlabroot/toolbox/javabuilder/jar/javabuilder.jar`) has been installed into your Web server’s common library folder.

### Locating the Example Files

The example files are located in the `matlabroot\toolbox\javabuilder\Examples\java_web_vararg_demo` folder.

### Contents of the Example Files

The example files contain the following three folders:

- `mcode` — Contains all of the MATLAB source code.
- `JavaCode` — Contains the required Java files and libraries.

- `compile` — Contains some helpful MATLAB functions to compile and clean up the example.

---

**Note:** As an alternative to compiling the example code manually and creating the application WAR (Web Archive) manually, you can run `compileVarArgServletDemo.m` in the `compile` folder. If you choose this option and want to change the locations of the output files, edit the values in `getVarArgServletDemoSettings.m`.

If you choose to run `compileVarArgServletDemo.m`, consult the `readme` file in the download for additional information and then skip to “Running the Web Deployment Example” on page 5-40.

---

## Build Your Java Package

Build your Java package by compiling your code into a deployable `.jar` file.

- 1 Open the Library Compiler app.
- 2 Create the Java package using the Library Compiler app to build a Java class that wraps around your MATLAB code.

To compile the Java package using the Library Compiler app, use the following information as you work through this example in “Compile Java Packages with Library Compiler App”:

|                 |                               |
|-----------------|-------------------------------|
| Project Name    | <code>vararg_java</code>      |
| Class Name      | <code>vararg_javaclass</code> |
| File to compile | <code>varargexample.m</code>  |

## Compiling Your Java Code

Use `javac` to compile the Java source file `VarArgServletClass.java` from example folder `JavaCode\src\VarArg`.

`javac.exe` should be located in the `bin` folder of your JDK installation.

Ensure your `classpath` is set to include:

- `javabuilder.jar` (shipped with the MATLAB Compiler SDK product)

- `vararg_java.jar` (shipped with the MATLAB Compiler SDK product)
- `servlet-api.jar` (in the example folder `JavaCode\lib`)

For more details about using `javac`, see the Oracle Web site.

### Generating the Web Archive (WAR) File

Web archive or WAR files are a type of Java Archive used to deploy J2EE and JSP servlets. To run this example you will need to use the `jar` command to generate the final WAR file that runs the application. To do this, follow these steps:

- 1 Add `javabuilder.jar` to the `WEB-INF\lib` directory. For more information, see “Helper Library Locations” in the *MATLAB Application Deployment Web Example Guide*.
- 2 Copy the JAR file created using the MATLAB Compiler SDK product into the `JavaCode\build\WEB-INF\classes\VarArg` example folder.
- 3 Copy the compiled Java class to the `JavaCode\build\WEB-INF\classes\VarArg` example folder.
- 4 From the folder `JavaCode`, use the `jar` command to generate the final WAR as follows:

```
jar cf VarArgServlet.war -C build .
```

---

**Caution** Don't omit the `.` parameter above, which denotes the current working folder.

---

---

**Caution** Placing `javabuilder.jar` in the `WEB-INF/Lib` folder for a single Web application generally works. However, if another application also places `javabuilder.jar` in its `WEB-INF/Lib` locations, problems may occur. The native resources associated with `javabuilder.jar` can be loaded only once in an application. Therefore, `javabuilder.jar` must only be visible to a single class loader.

---

For more information about the `jar` command, refer to the Oracle Web site.

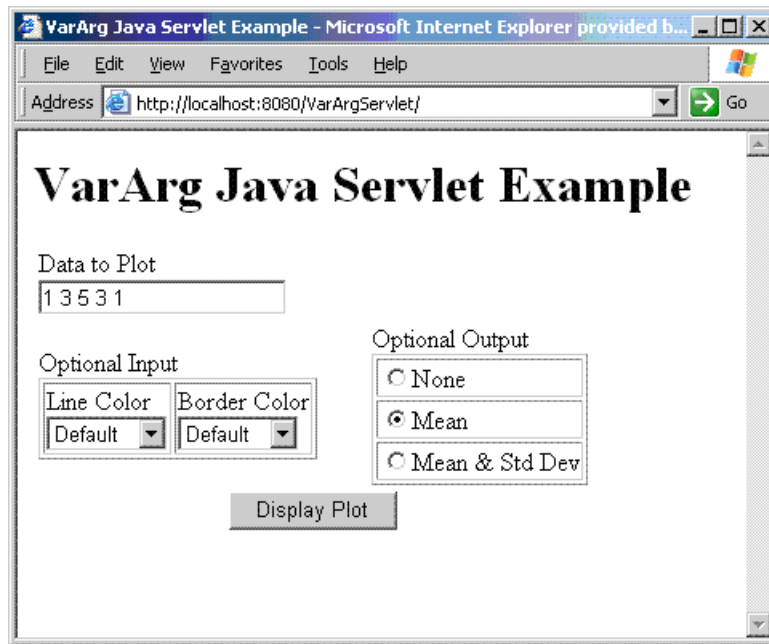
### Running the Web Deployment Example

When you're ready to run the application, do the following:

- 1 Install the `VarArgServlet.war` file into your Web server's `webapps` folder.
- 2 Run the application by entering `http://localhost:port_number/VarArgServlet` in the address field of your Web browser, where `port_number` is the port that your Web server is configured to use (usually 8080).

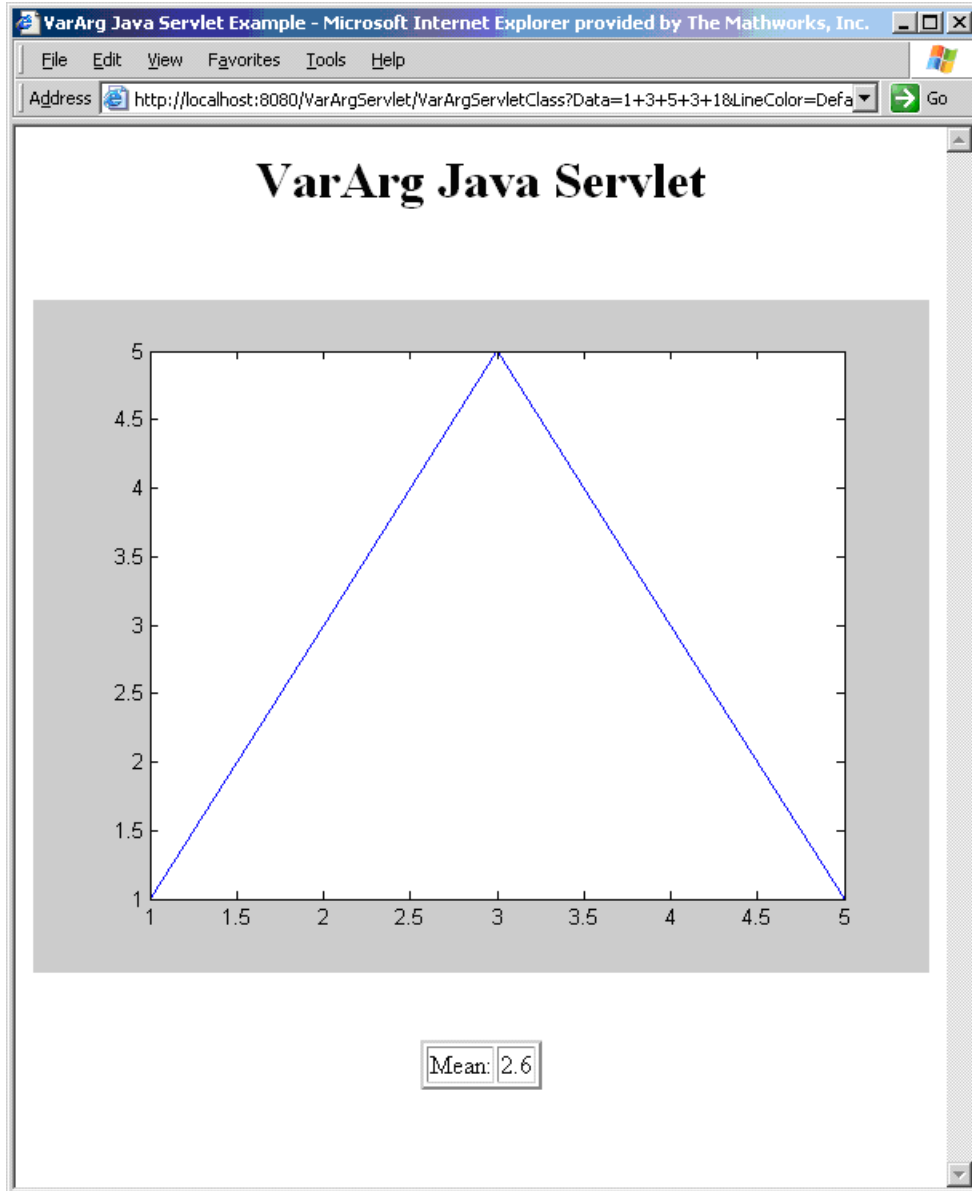
## Using the Web Application

To use the application, do the following on the `http://localhost/VarArgServlet` Web page:



- 1 Enter any amount of numbers to plot in the **Data to Plot** field.
- 2 Select **Line Color** and **Border Color** using the **Optional Input** drop-down lists. Note that these optional inputs are passed as `varargin` to the compiled MATLAB code.
- 3 Select additional information you want to output, such as mean and standard deviation, by clicking an option in the **Optional Output** area. Note that these optional outputs are set as `varargout` from the compiled MATLAB code.

- 4 Click **Display Plot**. Example output is shown below using the **Mean** optional output.





# Deploying a Java Package Over the Web

---

- “About the WebFigures Feature” on page 6-2
- “Prepare to Implement WebFigures” on page 6-3
- “Implement a Custom WebFigure” on page 6-5
- “Advanced Configuration of a WebFigure” on page 6-14

### About the WebFigures Feature

Using the WebFigures feature in MATLAB Compiler SDK, you display MATLAB figures on a Web site for graphical manipulation by end users. This enables them to use their graphical applications from anywhere on the Web without the need to download MATLAB or other tools that can consume costly resources. End users do not need to have the MATLAB Runtime installed on their systems to use WebFigures.

“Implement a Custom WebFigure” on page 6-5 guides you through implementing the basic features of WebFigures, and lets you customize your configuration depending on your server architecture.

### Supported Renderers for WebFigures

The MATLAB Compiler SDK WebFigures feature uses the same renderer used when the figure was originally created by the MATLAB renderer.

For more information about MATLAB renderers, see the MATLAB documentation.

---

**Note:** The WebFigures feature does not support the `Painter` renderer due to technical limitations. If this renderer is requested, the renderer `Zbuffer` will be invoked before the data is displayed on the Web page.

---

## Prepare to Implement WebFigures

### In this section...

“Required Products” on page 6-3

“Assumptions About the Examples” on page 6-3

“Set DISPLAY on Linux Systems” on page 6-4

### Required Products

Install the following products to implement WebFigures for MATLAB Compiler SDK, depending on your role.

#### MATLAB Programmer

- MATLAB
- MATLAB Compiler SDK
- MATLAB Compiler
- MATLAB Runtime (see the system requirements at [http://www.mathworks.com/support/sysreq/current\\_release/](http://www.mathworks.com/support/sysreq/current_release/))

#### Java Developer

- Java Developer's Kit (JDK) (see the list of supported compilers).
- J2EE compliant Web server, such as Apache Tomcat
- Java Runtime Environment (JRE) (see the system requirements).

---

**Note:** At this time, only J2EE Web servers that use the Oracle JVM™ support WebFigures.

---

### Assumptions About the Examples

To work with the examples in this chapter:

- Assume the following MATLAB function has been created:

```
function df = getKnot()
```

```
f = figure('Visible','off'); %Create a figure.
                                %Make sure it isn't visible.
knot;                            %Put something into figure.
df = webfigure(f);                %Give figure to function
                                % and return the result.
close(f);                        %Close the figure.
end
```

- Assume that the function `getKnot` has been deployed in a Java package with a namespace of `MyComponent.MyComponentclass`.
- Assume the MATLAB Runtime has been installed.

### Set DISPLAY on Linux Systems

If you are running on Linux, `WebFigures` requires a display to be available in the Web server's environment in order for text labels to be rendered properly.

Set the `DISPLAY` environment variable to a valid X Server before running the `WebFigure` application.

## Implement a Custom WebFigure

### In this section...

“Overview” on page 6-5

“Set Up the Web Server” on page 6-5

“Create the Default WebFigure” on page 6-9

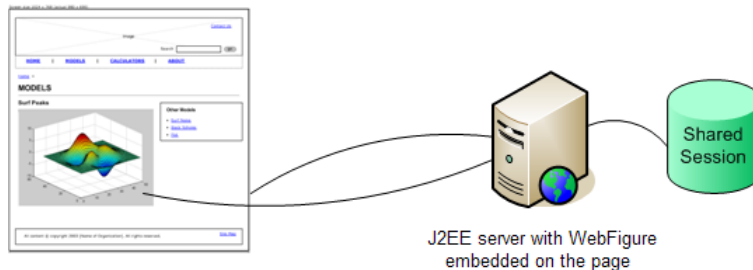
“Interact with the Default WebFigure” on page 6-10

“Create a Custom WebFigure” on page 6-11

### Overview

By following the Quick Start procedure, both the WebFigure service and the page that has the WebFigure embedded in it will be set up to reside on a single server. This configuration allows you to quickly reference your WebFigure from a JSP page with minimal configuration.

#### Using the WebFigure Control On the Frontend Servers



### Set Up the Web Server

Ensure that your Web server is properly configured with the required components by performing these steps:

- “Install and Configure Apache Tomcat” on page 6-6
- “Install `javabuilder.jar`” on page 6-7
- “Install the Web Archive (WAR)” on page 6-7

### Install and Configure Apache Tomcat

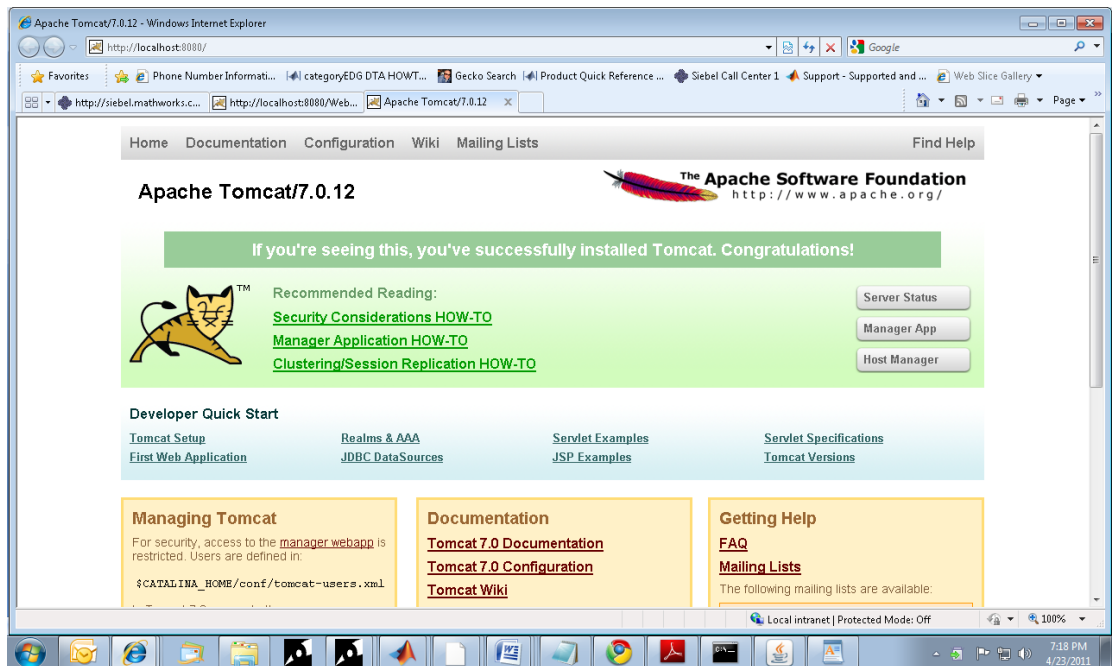
- 1 Download Apache Tomcat from the Apache Web site.
- 2 Install the product using an available port number. Note the port number you choose for future reference.
- 3 Navigate to *TomcatInstallDir\conf*.
- 4 Edit *tomcat-users.xml*.
- 5 Replace the section listing sample users and roles with the following.

```
<role rolename="manager-gui" />
<user username="tomcat" password="tomcat" roles="manager-gui" />
```

- 6 Save and close *tomcat-users.xml*.
- 7 Open a browser session and enter this URL:

`http://localhost:port_number/`

For example, if you chose port number 8080 when you installed Tomcat, you would enter: `http://localhost:8080/`. An image similar to the following should appear:



This image indicates that you have successfully set up Apache Tomcat.

### Install javabuilder.jar

Copy `javabuilder.jar` from `matlabroot\toolbox\javabuilder\jar\` to `TomcatInstallDir\lib`.

---

**Caution** This file uses native resources. It is critical that it exist in your Web server's class PATH only once. Embedding this file into Web applications causes errors.

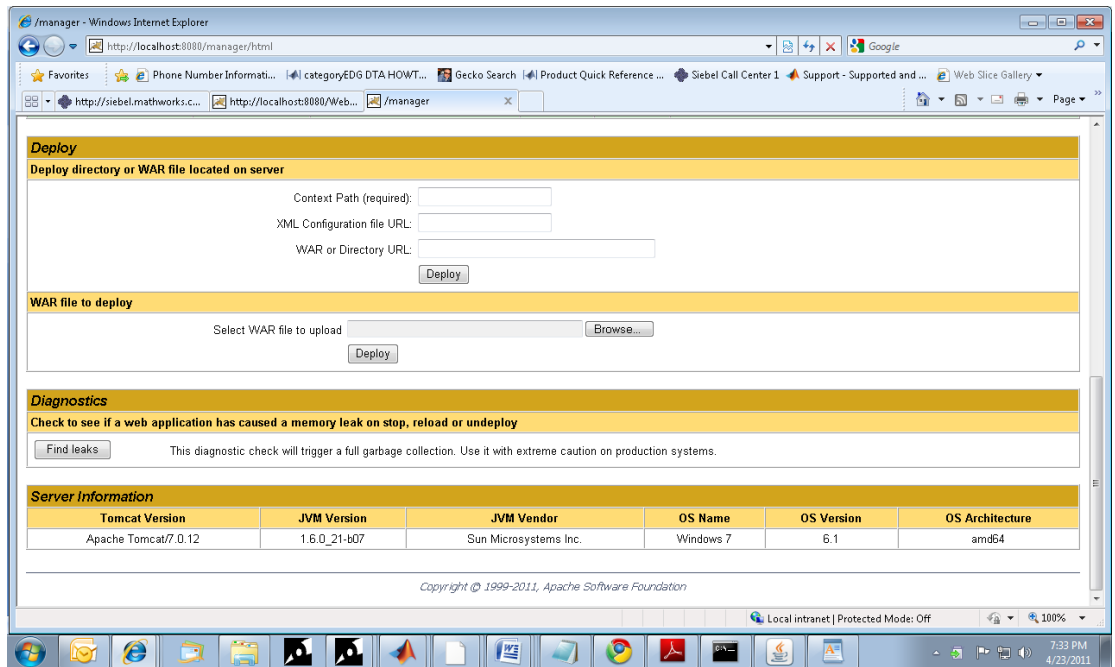
---

If you are using the MATLAB Runtime, *matlabroot* is the location of the installed MATLAB Runtime.

If you are using MATLAB Compiler SDK, *matlabroot* is the location of the installed MATLAB Compiler SDK.

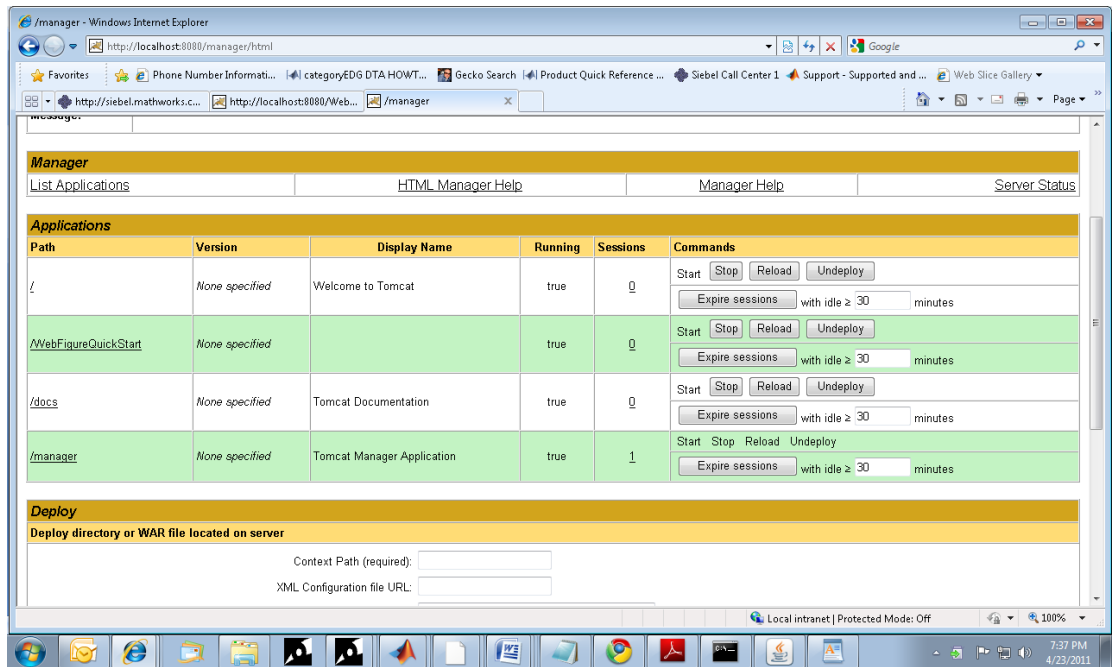
### Install the Web Archive (WAR)

- 1 In the browser session you started in “Install and Configure Apache Tomcat” on page 6-6, click the **Manager App** button, displayed in the above screenshot.
- 2 On the **Tomcat Web Application Manager** page, find the section **WAR File to Deploy**:



- 3 To the right of the field **Select WAR file to upload**, click **Browse**.
- 4 Select `matlabroot\toolbox\javabuilder\jar\WebFigureQuickStart.war`.
- 5 In the **WAR File to Deploy** section, click **Deploy**.
- 6 WebFigureQuickStart should now be listed in the **Applications** section of the **Tomcat Web Application Manager** page:



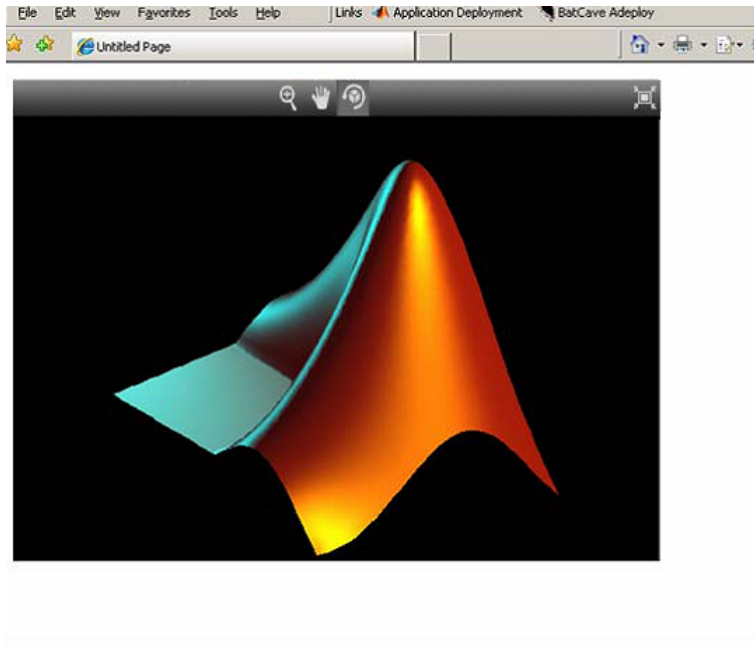


You are now ready to create your first WebFigure.

## Create the Default WebFigure

- 1 Start up your Web server.
- 2 Open a browser and navigate to the JSP file contained in the WebFigureQuickStart application. If you are running this locally, the URL is: `http://hostName:portNumber/WebFigureQuickStart/WebFigureExample.jsp`

The following default figure page appears:



### Behind the Scenes: How a WebFigure Is Referenced

The Web application that MathWorks ships contains a reference to a servlet in `WebFigureQuickStart.war` (installed in “Set Up the Web Server” on page 6-5). The JSP file instantiates a deployed class that is also in `WebFigureQuickStart.war` and attaches it to the application scope of the server. It uses the JSP tag to reference the figure on the page.

### Interact with the Default WebFigure

Interact with the default figure on the page using your mouse:

- 1 Click one of the three control icons at the top of the figure to select the desired control.
- 2 Select the region of the figure you want to manipulate.
- 3 Click and drag to manipulate the figure. For example, to zoom in the figure, click the magnifying glass icon, then hover over the figure.

## Create a Custom WebFigure

After you access the default figure, add one of your own figures:

- 1 Ensure you have done the following with the MATLAB code referenced in “Assumptions About the Examples” on page 6-3 (or your own MATLAB code):
  - Tested the code
  - Compiled the code using MATLAB Compiler SDK
  - Successfully generated the *yourcomponent.jar* file from the compilation.
- 2 Test to ensure that your Web server is functioning. You can do this by creating a JSP Web page, deploying it to your server, and then attempting to access it.
- 3 Create a new Web application and an associated JSP file within that application. In the `web.xml` file for your Web application (in the `WEB-INF` folder in a Web application), add the following reference to the built-in `WebFigureServlet`:

```
<servlet>
  <servlet-name>WebFigures</servlet-name>
  <servlet-class>
    com.mathworks.toolbox.javabuilder.webfigures.WebFiguresServlet
  </servlet-class>
</servlet>
<servlet-mapping>
  <servlet-name>WebFigures</servlet-name>
  <url-pattern>/WebFigures/*</url-pattern>
</servlet-mapping>
```

- 4 Copy `MATLABROOT/toolbox/javabuilder/webfigures/webfigures.tld`, the `WebFigures` customer tag handler file, to the `WEB-INF` folder under your Web application directory.
- 5 In the JSP file, add a reference to the `WebFigure` tag by including the following line of code at the beginning of the file. The URI listed here is for example purposes only.

```
<%@ taglib
  prefix="wf"
  uri="http://www.mathworks.com/builderja/webfigures.tld"
%>
```

- 6 Add an actual `WebFigure` tag in the body of the page:

```
<wf:web-figure />
```

- 7 At this point, test that the configuration is working properly following the changes you previously made. By having an empty `WebFigure` tag, the `WebFigureService`

automatically displays the default WebFigure and the resulting page should resemble that achieved in “Create the Default WebFigure” on page 6-9.

**8** Reference the previously built and deployed package from your JSP page:

**a** Add the following import statement to your JSP page:

```
<%@ page import="yourComponentsPackage.YourComponentsClass" %>
```

**b** Add the following import statement to invoke the WebFigure:

```
<%@ page import="com.mathworks.toolbox.javabuilder.webfigures.WebFigure" %>
```

**c** Add the following statement to enable access to MWJavaObjectRef:

```
<%@ page import="com.mathworks.toolbox.javabuilder.*" %>
```

**9** Instantiate the deployed class and call the method that will return the WebFigure:

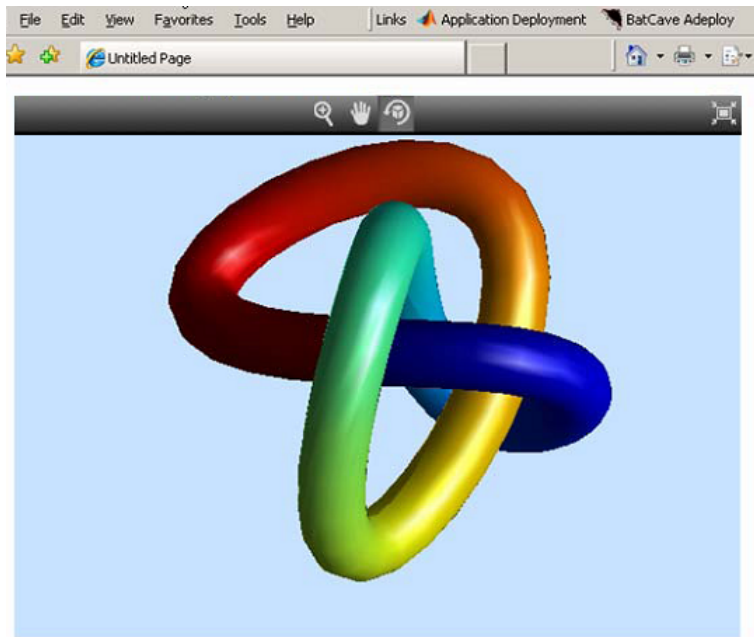
```
<%! MyClass myDeployedComponent; %>
<%!
    public void jspInit()
    {
        try {
            //Instantiate the Deployed Component
            myDeployedComponent = new MyClass();
        } catch (Exception e)
        {
            e.printStackTrace();
        }
    }
%>
<%!
    public void jspDestroy()
    {
        if (myDeployedComponent!=null)
        {
            myDeployedComponent.dispose();
        }
        myDeployedComponent = null;
    }
%>
<%
    if (myDeployedComponent!=null)
    {
        try
        {
            WebFigure webFigure = (WebFigure)
                ((MWJavaObjectRef)myDeployedComponent.myMethod(1)[0]).get();

            //Get the WebFigure from your function's output
            // and set it to the tag
            request.getSession().setAttribute("MyFigure", webFigure);
        } catch(ClassCastException e)
    }
%>
```

```
    {
        throw new Exception("Issue casting deployed components outputs to WebFigure", e);
    } catch (Exception e)
    {
        e.printStackTrace();
    }
} else {
    out.println("no go");
}
%>
```

```
<wf:web-figure name="YourFigure" scope="session" />
```

- 10** Run your application. Your custom WebFigure appears:



## Advanced Configuration of a WebFigure

### In this section...

“Overview” on page 6-14

“How Do WebFigures Work?” on page 6-16

“Installing WebFigureService” on page 6-17

“Getting the WebFigure Object from Your Method” on page 6-18

“Attach a WebFigure” on page 6-19

“Using the WebFigure JSP Tag to Reference a WebFigure” on page 6-20

“Getting an Embeddable String That References a WebFigure Attached to a Cache” on page 6-22

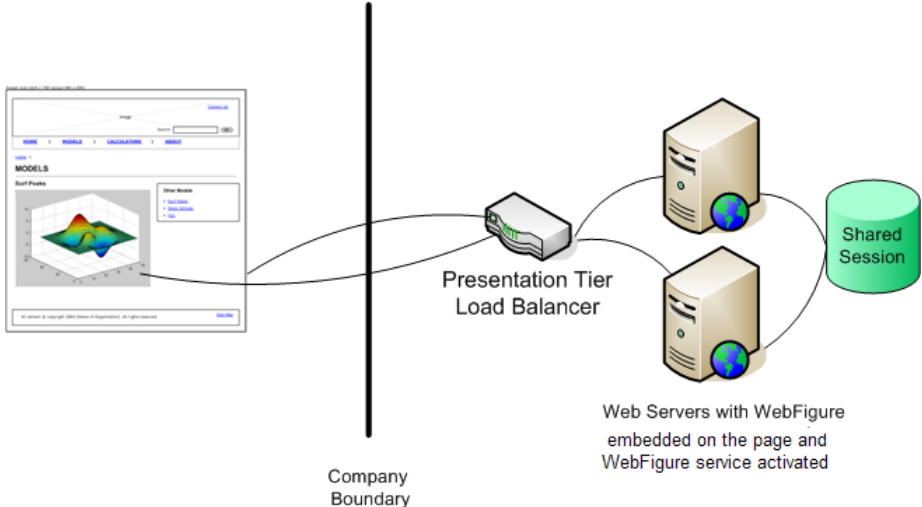
### Overview

The advanced configuration gives the experienced application developer flexibility and control in configuring system architecture based on differing needs. For example, with the `WebFigureService` and the Web page on different servers, the administrator can optimally position the MATLAB Runtime (for performance reasons) or place customer-sensitive customer data behind a security firewall, if needed.

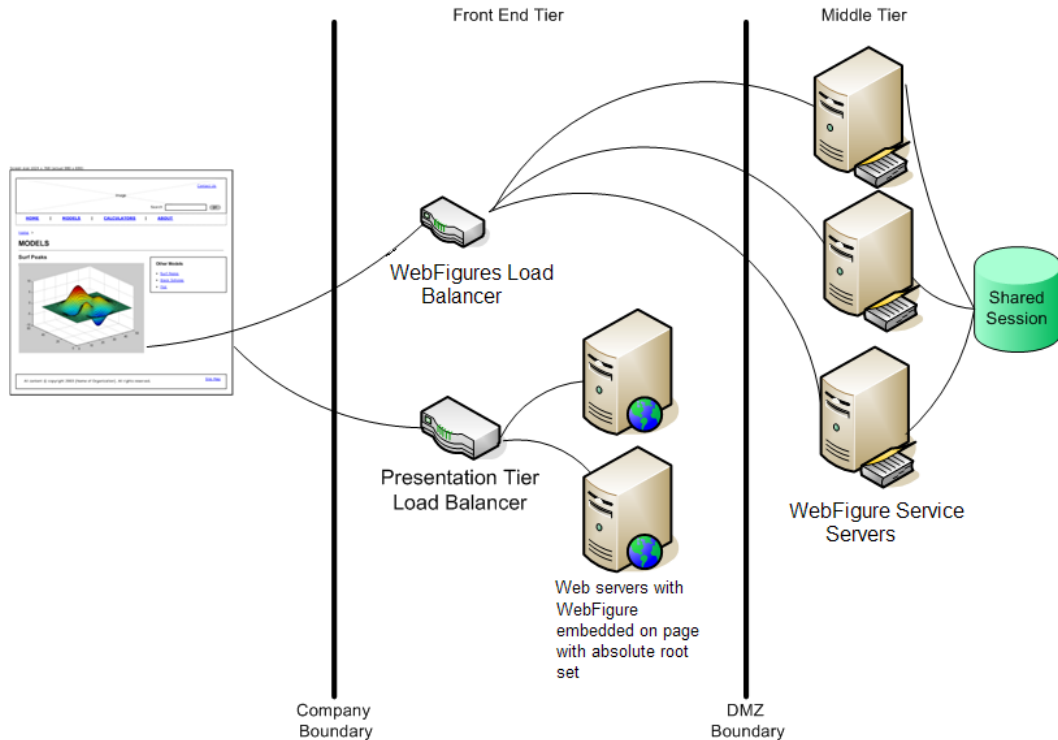
This section describes various ways to customize the basic WebFigures implementation described in “Implement a Custom WebFigure” on page 6-5.

The advanced configuration offers more choices and adaptability for the user more familiar with Web environments and related technology, as illustrated by the following graphics.

### Using the Web Figure Control On the Frontend Servers



### Using Absolute Root to Keep the WebFigure Service Cluster Behind the Firewall



## How Do WebFigures Work?

When choosing the best architecture for your configuration, it is important to understand the fundamental components that enable an application.

WebFigures is made up of several different components that work together:

- Your Web application
- Client-side code
- WebFigureService
- Your server's cache



When you enable a user to rotate a figure, for example, you are using standard AJAX techniques to request different static images depending on the requested orientation. `WebFiguresService` (which is exposed by referencing `WebFigureServlet` in `web.xml`) delivers the HTML and JavaScript<sup>®</sup> to a browser, getting the defaults for a figure, and rendering a figure in any of its available orientations.

Your Web application calls one of your deployed components to get the specific `WebFigure`, and attaches it to your server's cache for `WebFiguresService` to use later. Your application also puts an HTML reference to your `WebFigure` on a page. This can either be done automatically using the JSP tag or manually by using `WebFigureHtmlGenerator`. This gives the client browser what it needs to request the client-side code.

The client-side JavaScript AJAX code provides a user experience similar to that in MATLAB when using a `FIGURE`. It provides rotation, zooming, and panning in a highly usable medium by using a JavaScript application that monitors for user interaction such as dragging or clicking with a mouse, and calls back into `WebFiguresService` to service those requests.

For example, when a user selects the rotate icon and clicks in the `WebFigureTag` and drags it, that drag translates to coordinates and issues a request for the new rotated image from `WebFiguresService`. A rotating cube is displayed so the user knows what orientation they are looking at. Since there is no efficient way to pass an actual `WebFigure` from your application to the client-side application and then back to `WebFiguresService`, the server's built-in cache is leveraged as a central repository.

## Installing WebFigureService

In order for the client-side code to call back to request images, you need a reference to the built-in servlet in the application's `web.xml` file. This reference should look like this:

```
<servlet>
    <servlet-name>WebFigures</servlet-name>
    <servlet-class>
        com.mathworks.toolbox.javabuilder.webfigures.WebFiguresServlet
    </servlet-class>
</servlet>
<servlet-mapping>
    <servlet-name>WebFigures</servlet-name>
    <url-pattern>/WebFigures/*</url-pattern>
</servlet-mapping>
```

---

**Note:** You can rename the servlet and its mapping. If you do, you must reference it whenever you interact with either the `WebFigureHtmlGenerator` or the JSP tag (using the `root` attribute) so it can call back to the servlet. It is critical that the URL pattern you map to ends with the literal `/*`. This allows all end points to be redirected to the servlet. To test this end point at any time, navigate to it in a browser and you should see the default Web page. If you have `web.xml` set correctly in your application, the URL will look something like `http://hostName:portNumber/yourWebApplication/WebFigures`.

---

### Getting the WebFigure Object from Your Method

In MATLAB Compiler SDK, when a `WebFigure` Java Object is created in MATLAB code and returned, you convert that `MWJavaObjectRef` into a regular `WebFigure` in order to access it. For example:

```
try
{
    Object[] results = null;
    try
    {
        //This assumes there is only a single option
        // from your function
        // and it has no inputs.
        results = myDeployedComponent.getSurfPeaks(1);

        //Since we know the only output is the WebFigure
        // we get the MWJavaObjectRef from
        // the Object Array.
        //By calling "get" on the MWJavaObjectRef we
        // retrieve the
        // actual object from it.
        WebFigure myFigure =
            (WebFigure)((MWJavaObjectRef)results[0]).get();
    }
    finally
    {
        //Deployed Components use MWArrays which utilize
        // Native Resources.
        //The Java Garbage collector can not properly
        // clean up this memory so it is important to
        // dispose these resources.
        MWArray.disposeArray(results);
    }
}
```

```
    }  
}  
catch(ClassCastException e)  
{  
    throw new Exception  
        ("WebFigure object was not  
         of Type WebFigure.", e);  
}
```

## Attach a WebFigure

All components access available WebFigures is by using Web server cache mechanisms. This allows you to leverage built-in J2EE mechanisms to scale your servers into a farm and automatically propagate the session across the servers.

There are a number of ways to attach a WebFigure to a scope, depending on the state:

- Attaching to the session cache session
- Attaching to the application cache application

### Attaching to the Session Cache

This cache is visible only to the current user in a system and is usually used to store user session-specific information.

Attaching to the session cache can be an ideal choice if the figure is valid only for a specific user, at a certain time. To do this, add the following line of code to a JSP scriptlet or a servlet:

```
//from a JSP scriptlet or a servlet to the Session cache  
request.getSession().setAttribute("myFigure", myFigure);
```

If you manually attached the figure, but want the JSP tag to reference it, you can add the tag attributes:

```
name="myFigure" scope="session"
```

---

**Note:** The name given to the JSP tag must match the one used to attach it to a cache, and the name must be unique within that cache.

---

### Attaching to the Application Cache

This cache is visible by all sessions in the current application. Attach to the application cache if you want to attach the figure globally for every page and servlet to use.

To attach to the Application scope, add the following line of code to a JSP scriptlet or a servlet:

```
//from a JSP scriptlet or a servlet to the Application cache
request.getSession().getServletContext().setAttribute("GlobalFigure",
    myFigure);
```

If you manually attached the figure, but want the JSP tag to reference it, you can add the tag attributes:

```
name="GlobalFigure" scope="application"
```

---

**Note:** The name given to the JSP tag must match the one used to attach it to a cache, and the name must be unique within that cache.

---

### Using the WebFigure JSP Tag to Reference a WebFigure

Once the WebFigure has been retrieved from the function output (see “Getting the WebFigure Object from Your Method” on page 6-18), you can attach it to one of your server's caches and reference it from the JSP tag.

#### Initializing the JSP Tag

Reference the tag library by adding the following line to a JSP page:

```
<%@ taglib
    prefix="wf"
    uri="http://www.mathworks.com/builderja/webfigures.tld"
%>
```

---

**Note:** This code references the `.tld` file from the `WEB-INF` folder under your web application folder. This URI must be typed exactly as shown above for the name to properly resolve the reference. Once this tag has been referenced, you can add tags to the page similar to this:

```
<wf:web-figure />
```

---

---

**Note:** If you use an empty tag as shown above, the default WebFigure appears. To bind the tag to your WebFigure, see “Attach a WebFigure” on page 6-19.

---

### Attributes of a WebFigure Tag

The key attributes for the WebFigure tag are **name** and **scope**. For each tag, use these parameters to indicate which figure to use in which cache on your server. Assuming you have attached a figure to the session cache using the string **MyFigure** (as shown in the “Attach a WebFigure” on page 6-19), the JSP tag resembles this:

```
<wf:web-figure name="MyFigure" scope="session" />
```

Use this table to reference the following WebFigure tag attributes.

#### WebFigure Tag Attributes and Their Default Values

Attribute Name	Description	Optional?	Default Value
name	Name used when attaching your figure to a cache. Case sensitive.	Yes	The name of the default WebFigure built into WebFigureService. If you provide an empty WebFigure tag, this figure is displayed.
scope	Scope that your figure has been saved to (either <b>application</b> or <b>session</b> ).	Yes	If this is not specified, an error is thrown unless the name is also not specified. In this case, the default figure is attached to the session scope and is used.
style	Style attribute that you want embedded and attached to the iFrame.	Yes	If this is not passed, a basic iFrame is used.
height	Height of the iFrame that will be embedded.	Yes	If this is not passed, the height of the WebFigure is retrieved from cache.

Attribute Name	Description	Optional?	Default Value
width	Width of the iFrame that will be embedded.	Yes	If this is not passed, the width of the WebFigure is retrieved from cache.
root	Name used to map the WebFiguresServlet for a figure.	Yes	If this is not specified, it is assumed to be mapped to WebFigures. If it is specified to a relative servlet end point, that is used.

## Getting an Embeddable String That References a WebFigure Attached to a Cache

If you do not want to use the WebFigure JSP tag to display the figure, or want a servlet to display it directly, use this method to get a snippet of HTML that will embed an iFrame containing the figure in another page.

- 1 Create an instance of the `WebFigureHtmlGenerator` class using either a scriptlet or a servlet. The constructor for this class has three overloads:

```
//The import statement needed to invoke this class
import com.mathworks.toolbox.javabuilder.webfigures.WebFigureHtmlGenerator;

//WebFigureHtmlGenerator(HttpServletRequest servletRequest)
//This overload just takes the ServletRequest and will map the
// embed string to the same server and assumes that the
// WebFiguresService was mapped to "WebFigures"
WebFigureHtmlGenerator htmlGenerator =
    WebFigureHtmlGenerator(servletRequest);

//OR

//WebFigureHtmlGenerator(String webFigureServletNameMapping, HttpServletRequest
// servletRequest)
//This overload takes the ServletRequest and the name that
// the WebFigureServlet was mapped to.
//It will reference this servlet on the same server
WebFigureHtmlGenerator htmlGenerator =
    WebFigureHtmlGenerator("SomeServletMappingName", servletRequest);

//OR

//WebFigureHtmlGenerator(String absolutePathName)
//This overload takes the absolute URL path to a server that has
// WebFiguresService running.
```

```
//This would be used if you have a cluster of servers that are all running
// WebFigureService
// a load balancer (all sharing cache state). Use
// this parameter to reference that base load balancer URL.
WebFigureHtmlGenerator htmlGenerator =
    WebFigureHtmlGenerator("http://someLoadBalancer/someWebApplication/
                            WebFigureServletNameMapping");
```

- 2 Call the method to get the embedded string (`getFigureEmbedString`). Use this table to specify appropriate attributes:

Attribute Name	Attribute Type	Description	Optional	Default Value
figure	WebFigure	WebFigure for which you want to create the embedded string.	Yes	This is used to determine the figure's default height and width if no other is provided .
name	String	Name used when attaching your figure to a cache. Case sensitive.	No	Not optional
scope	String	Scope that figure has been saved to (application or session).	No	Not optional
style	String	Embedded attribute you want attached to the iFrame.	Yes	If this is not passed, a basic iFrame is used.
height	String	Height of the iFrame that will be embedded.	Yes	If this is not passed, the height of the WebFigure is retrieved from cache. If the WebFigure cannot be found, the MATLAB default height for a figure (420) is used.

Attribute Name	Attribute Type	Description	Optional	Default Value
width	String	Width of the iFrame that will be embedded.	Yes	If this is not passed, the width of the WebFigure is retrieved from cache. If the WebFigure cannot be found, the MATLAB default width for a figure (560) is used.



# Working with MATLAB Figures and Images

---

- “Roles in Working with Figures and Images” on page 7-2
- “Create and Modify a MATLAB Figure” on page 7-3
- “Work with MATLAB Figure and Image Data” on page 7-6

### Roles in Working with Figures and Images

When you work with figures and images as a MATLAB programmer, you are responsible for:

- Preparing a MATLAB figure for export
- Making changes to the figure (optional)
- Exporting the figure
- Cleaning up the figure window

When you work with figures and images as a front-end Web developer, some of the tasks you are responsible for include:

- Getting a WebFigure from a deployed component
- Getting raw image data from a deployed component converted into a byte array
- Getting a buffered image from a component
- Getting a buffered image or a byte array from a WebFigure

# Create and Modify a MATLAB Figure

## In this section...

“Preparing a MATLAB Figure for Export” on page 7-3

“Changing the Figure (Optional)” on page 7-3

“Exporting the Figure” on page 7-4

“Cleaning Up the Figure Window” on page 7-4

“Modify and Export Figure Data” on page 7-4

## Preparing a MATLAB Figure for Export

- 1 Create a figure window. For example:

```
h = figure;
```

- 2 Add graphics to the figure. For example:

```
surf(peaks);
```

## Changing the Figure (Optional)

Optionally, you can change the figure numerous ways. For example:

### Alter Visibility

```
set(h, 'Visible', 'off');
```

### Change Background Color

```
set(h, 'Color', [.8,.9,1]);
```

### Alter Orientation and Size

```
width=500;  
height=500;  
rotation=30;  
elevation=30;  
set(h, 'Position', [0, 0, width, height]);  
view([rotation, elevation]);
```

## Exporting the Figure

Export the contents of the figure in one of two ways:

### WebFigure

To export as a WebFigure:

```
returnFigure = webfigure(h);
```

### Image Data

To export image data, for example:

```
imgform = 'png';  
returnByteArray = figToImStream(`figHandle', h, ...  
    `imageFormat', imgform, ...  
    `outputType', `uint8');
```

## Cleaning Up the Figure Window

To close the figure window:

```
close(h);
```

## Modify and Export Figure Data

### WebFigure

```
function returnFigure = getWebFigure()  
h = figure;  
set(h, 'Visible', 'off');  
surf(peaks);  
set(h, 'Color', [.8,.9,1]);  
returnFigure = webfigure(h);  
close(h);
```

### Image Data

```
function returnByteArray = getImageDataOrientation(height,  
    width, elevation, rotation, imageFormat )  
h = figure;  
set(h, 'Visible', 'off');
```

```
surf(peaks);
set(h, 'Color', [.8,.9,1]);
set(h, 'Position', [0, 0, width, height]);
view([rotation, elevation]);
returnByteArray = figToImStream(`figHandle', h, ...
                                `imageFormat', imageFormat, ...
                                `outputType', `uint8');

close(h);

function returnByteArray = getImageDataOrientation(height,
  width, elevation, rotation, imageFormat )
h = figure;
set(h, 'Visible', 'off');
surf(peaks);
set(h, 'Color', [.8,.9,1]);
set(h, 'Position', [0, 0, width, height]);
view([rotation, elevation]);
returnByteArray = figToImStream(`figHandle', h, ...
                                `imageFormat', imageFormat, ...
                                `outputType', `int8');

close(h);
```

## Work with MATLAB Figure and Image Data

<b>In this section...</b>
“For More Comprehensive Examples” on page 7-6
“Working with Figures” on page 7-6
“Working with Images” on page 7-6

### For More Comprehensive Examples

This section contains code snippets intended to demonstrate specific functionality related to working with figure and image data.

To see these snippets in the context of more fully-functional multi-step examples, see the *“Use MATLAB Application Deployment Web Example Guide”*.

### Working with Figures

#### Getting a Figure From a Deployed Component

For information about how to retrieve a figure from a deployed component, see “Implement a Custom WebFigure” on page 6-5

### Working with Images

#### Getting Encoded Image Bytes from an Image in a Component

```
public byte[] getByteArrayFromDeployedComponent()
{
    Object[] byteImageOutput = null;
    MWNumericArray numericImageByteArray = null;
    try
    {
        byteImageOutput =
            deployment.getImageDataOrientation(
                1, //Number Of Outputs
                500, //Height
                500, //Width
                30, //Elevation
                30, //Rotation
            );
    }
}
```

```

        "png"    //Image Format
    );

    numericImageByteArray =
        (MWNumericArray)byteImageOutput[0];
    return numericImageByteArray.getBytesData();
}
finally
{
    MWArray.disposeArray(byteImageOutput);
}
}

```

### Getting a Buffered Image in a Component

```

public byte[] getByteArrayFromDeployedComponent()
{
    Object[] byteImageOutput = null;
    MWNumericArray numericImageByteArray = null;
    try
    {
        byteImageOutput =
            deployment.getImageDataOrientation(
                1,    //Number Of Outputs
                500, //Height
                500, //Width
                30,  //Elevation
                30,  //Rotation
                "png" //Image Format
            );

        numericImageByteArray =
            (MWNumericArray)byteImageOutput[0];
        return numericImageByteArray.getBytesData();
    }
    finally
    {
        MWArray.disposeArray(byteImageOutput);
    }
}

public BufferedImage getBufferedImageFromDeployedComponent()
{
    try
    {

```

```
        byte[] imageByteArray =
            getByteArrayFromDeployedComponent()
        return ImageIO.read
            (new ByteArrayInputStream(imageByteArray));
    }
    catch(IOException io_ex)
    {
        io_ex.printStackTrace();
    }
}
```



# Creating Scalable Web Applications Using RMI

---

- “Use Remote Method Invocation (RMI)” on page 8-2
- “RMI Prerequisites” on page 8-3
- “Run Client and Server on Same Machine” on page 8-4
- “Run Client and Server on Separate Machines” on page 8-7
- “Why Use Native Cell Arrays and Struct Arrays?” on page 8-8
- “Native Data Marshaling Prerequisites” on page 8-9
- “Use Native Java Cell and Struct Arrays” on page 8-10
- “Additional RMI Examples” on page 8-14

## Use Remote Method Invocation (RMI)

You can expand your application's throughput capacity by taking advantage of RMI, the Java native remote procedure call (RPC) mechanism. The way the MATLAB Compiler SDK product implements RMI technology provides for automatic generation of interface code to enable components to start in separate processes, on one or more computers, making your applications scalable and adaptable to future performance demands.

The following example uses RMI in the following ways:

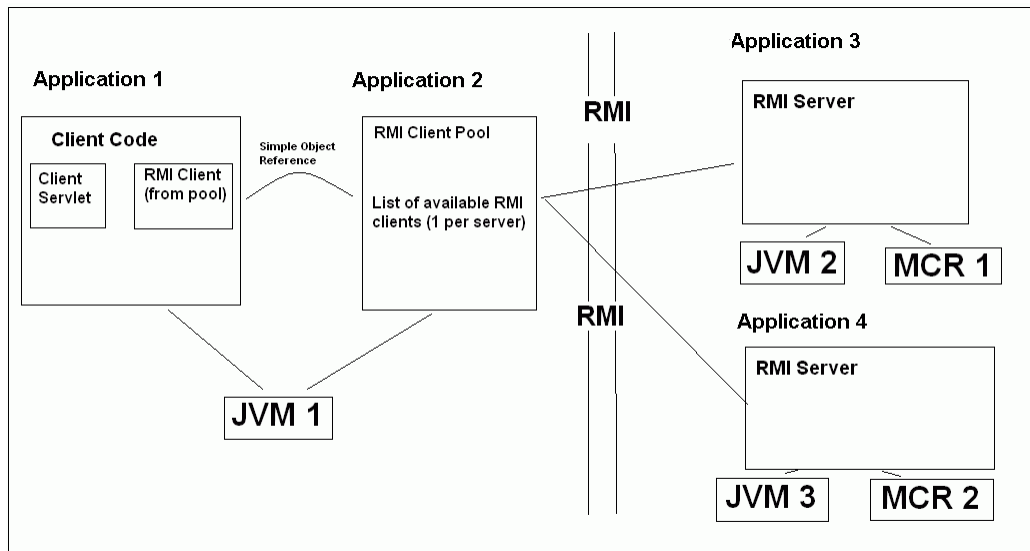
- Running a client and server on a single machine
- Running a client and server on separate machines

---

**Tip** While running on UNIX, ensure you use `:` as the path separator in calls to `java` and `javac`.

`;` is used as a path separator only on Windows.

---



## RMI Prerequisites

See “Display a MATLAB Plot in a Web Application” on page 5-37 for information on properly setting up your Java environment before you run the example in this section.

## Run Client and Server on Same Machine

The following example shows how to run two separate processes to initialize MATLAB struct arrays.

---

**Note:** You do not need the MATLAB Runtime installed on the client side. Return values from the MATLAB Runtime can be automatically converted using the `marshalOutputs` Boolean in the `RemoteProxy` class. See the Javadoc API documentation for details at <matlabroot/help/toolbox/javabuilder/MWArrayAPI>.

---

- 1 Compile the Java package by issuing the following command at the MATLAB command prompt:

```
mcc -W 'java:dataTypesComp,dataTypesClass'  
                                     createEmptyStruct.m  
updateField.m -v
```

- 2 Compile the server Java code by issuing the following `javac` command. Ensure there are no spaces between `javabuilder.jar`; and *directory\_containing\_package*.

```
javac -classpath  
matlabroot\toolbox\javabuilder\jar\javabuilder.jar;  
directory_containing_package\dataTypesComp.jar  
DataTypesServer.java
```

You can find `DataTypesServer.java` in:

```
matlabroot\toolbox\javabuilder\Examples\RMIExamples  
\DataTypes\DataTypesDemoJavaApp
```

- 3 Compile the client Java code by issuing the following `javac` command. Ensure there are no spaces between `javabuilder.jar`; and *directory\_containing\_package*.

```
javac -classpath  
matlabroot\toolbox\javabuilder\jar\javabuilder.jar;  
directory_containing_package\dataTypesComp.jar DataTypesClient.java
```

- 4 Run the client and server as follows:
  - a Open two command windows.

- b** If running Windows, ensure that *matlabroot/runtime/arch* is defined on the system path. If running UNIX, ensure `LD_LIBRARY_PATH` and `DYLD_LIBRARY_PATH` are set properly.
- c** Run the server by issuing the following `java` command. Ensure there are no spaces between `dataTypesComp.jar`; and *matlabroot*.

```
java -classpath
.;directory_containing_pacakage\dataTypesComp.jar;
matlabroot\toolbox\javabuilder\jar\javabuilder.jar
-Djava.rmi.server.codebase=
"file:///matlabroot/toolbox/javabuilder/jar/javabuilder.jar
file:///directory_containing_pacakage/dataTypesComp.jar"
DataTypesServer
```

- d** Run the client by issuing the following `java` command. Ensure there are no spaces between `dataTypesComp.jar`; and *matlabroot*.

```
java -classpath
.;directory_containing_pacakage\dataTypesComp.jar;
matlabroot\toolbox\javabuilder\jar\javabuilder.jar
DataTypesClient
```

You can find `DataTypesClient.java` in: *matlabroot\toolbox\javabuilder\Examples\RMIEamples\DataTypes\DataTypesDemoJavaApp*.

If successful, the following output appears in the Command Window running the server:

```
Please wait for the server registration notification.
Server registered and running successfully!!

EVENT 1: Initializing the structure on server
and sending it to client:
Initialized empty structure:

Name: []
Address: []

#####

EVENT 3: Partially initialized structure as received by server:

Name: []
Address: [1x1 struct]

Address field as initialized from the client:

Street: '3, Apple Hill Drive'
```

```
City: 'Natick'  
State: 'MA'  
Zip: '01760'
```

```
#####
```

```
EVENT 4: Updating 'Name' field before  
        sending the structure back to the client:
```

```
        Name: 'The MathWorks'  
        Address: [1x1 struct]
```

```
#####
```

If successful, the following output appears in the Command Window running the client:

```
Running the client application!!
```

```
EVENT 2: Initialized structure as received in client applications:
```

```
        Name: []  
        Address: []
```

```
Updating the 'Address' field to :
```

```
        Street: '3, Apple Hill Drive'  
        City: 'Natick'  
        State: 'MA'  
        Zip: '01760'
```

```
#####
```

```
EVENT 5: Final structure as received by client:
```

```
        Name: 'The MathWorks'  
        Address: [1x1 struct]
```

```
Address field:
```

```
        Street: '3, Apple Hill Drive'  
        City: 'Natick'  
        State: 'MA'  
        Zip: '01760'
```

```
#####
```

## Run Client and Server on Separate Machines

To implement RMI with a client on one machine and a server on another, you must:

- 1 Change how the server is bound to the system registry.
- 2 Redefine how the client accesses the server.

After this is done, follow the steps in “Run Client and Server on Same Machine” on page 8-4.

## Why Use Native Cell Arrays and Struct Arrays?

In Java, there is no direct representation available for MATLAB struct arrays and cell arrays.

As a result, when an instance of `MWStructArray` or `MWCellArray` is converted to a Java native type using the `toArray()` method, the output is a multi-dimensional `Object` array which can be difficult to process.

When you use MATLAB Compiler SDK packages with RMI, however, you have control over how the server sends the results of MATLAB function calls back to the client. The server can be set to marshal the output to the client as an `MWArray` (`com.mathworks.toolbox.javabuilder` package) sub-type or as a Java™ native data type. The Java native data type representation of `MWArray` subtypes is obtained by invoking the `toArray()` method by the server.

Using Java native representations of MATLAB struct and cell arrays is recommended if both of these are true:

- You have MATLAB functions on a server with MATLAB struct or cell data types as inputs or outputs
- You do not want or need to install an MATLAB Runtime on your client machines

## Using Native Types Does Not Require a Client-Side MATLAB Runtime

The classes in the `com.mathworks.extern.java` package (in `javabuilder.jar`) do not need an MATLAB Runtime. The names of the classes in this package are the same as those in `com.mathworks.toolbox.javabuilder` — allowing the end-user to easily create instances of `com.mathworks.extern.java.MWStructArray` or `com.mathworks.extern.java.MWCellArray` that work the same as the like-named classes in `com.mathworks.toolbox.javabuilder` — on a machine that does not have a MATLAB Runtime.

The availability of a MATLAB Runtime on the client machine dictates how the server should be set for marshaling MATLAB functions, since the `MWArray` class hierarchy can be used only with a MATLAB Runtime. If the client machine does not have a MATLAB Runtime available, the server returns the output of `toArray()` for cell or struct arrays as instances of `com.mathworks.extern.java.MWStructArray` or `com.mathworks.extern.java.MWCellArray`.



## Native Data Marshaling Prerequisites

Even though client machines don't need to have a MATLAB Runtime, they do need to have `javabuilder.jar` since it contains the `com.mathworks.extern.java` package.

Please refer to the Javadoc (*[matlabroot/help/toolbox/javabuilder/MWArrayAPI](#)*) for more information about classes in all MATLAB Compiler SDK Java packages.

## Use Native Java Cell and Struct Arrays

### Before You Run the Example

Before you run this example, note the following:

- This example demonstrates how to implement RMI when the client and the server are running on the same machine. See “Run Client and Server on Separate Machines” on page 8-7 if you would like to do otherwise.
- On UNIX, use `:` as the path separator in calls to `java` and `javac`. Use `;` as a path separator on Windows.
- Only update the server system path with the location of the MATLAB Runtime. The client does not need access to the MATLAB Runtime.
- This example is shipped in the `matlab\toolbox\javabuilder\Examples\RMIEamples\NativeCellStruct` directory.
- Ensure that:
  - On Windows systems, `matlabroot/runtime/arch` is on the system path.
  - On UNIX systems, `LD_LIBRARY_PATH` and `DYLD_LIBRARY_PATH` are set properly. See “MATLAB Runtime Path Settings for Run-Time Deployment” for further information on setting the path.

### Running the Example

---

**Note:** Be sure to enter the following as single, unbroken commands.

---

- 1 Use the following `mcc` command to build the package:

```
mcc -W 'java:dataTypesComp,dataTypesClass' createEmptyStruct.m  
updateField.m -v
```

- 2 Compile the server's Java code:

```
javac -classpath matlabroot\toolbox\javabuilder\jar\javabuilder.jar;  
directory_containing_package\dataTypesComp.jar NativeCellStructServer.java
```

- 3 Compile the client's Java code:

```
javac -classpath matlabroot\toolbox\javabuilder\jar\javabuilder.jar;
```

```
directory_containing_pacakage\dataTypesComp.jar
NativeCellStructClient.java
```

- 4 Prepare to run the server and client applications by opening two command windows—one for client and one for server.

- 5 Run the server:

```
java -classpath .;directory_containing_pacakage\dataTypesComp.jar;
      matlabroot\toolbox\javabuilder\jar\javabuilder.jar
-Djava.rmi.server.codebase="file:///matlabroot/toolbox/javabuilder/
jar/javabuilder.jar file:///
directory_containing_pacakage/dataTypesComp.jar"
NativeCellStructServer
```

- 6 Run the client:

```
java -classpath .;directory_containing_pacakage\dataTypesComp.jar;
      matlabroot\toolbox\javabuilder\jar\javabuilder.jar NativeCellStructClient
```

- 7 If your application has run successfully, the output will display as follows:

- **Server output:**

```
Please wait for the server registration notification.
Server registered and running successfully!!
```

```
EVENT 1: Initializing the structure on server and
         sending it to client:
         Initialized empty structure:
```

```
Name: ' '
Address: []
```

```
#####
```

```
EVENT 3: Partially initialized structure as received
         by server:
```

```
Name: ' '
Address: [1x1 struct]
```

```
Address field as initialized from the client:
```

```
Street: '3, Apple Hill Drive'
City: 'Natick'
```

```
State: 'MA'  
Zip: '01760'
```

```
#####
```

```
EVENT 4: Updating 'Name' field before sending the  
structure back to the client
```

```
Name: 'The MathWorks'  
Address: [1x1 struct]
```

```
#####
```

- **Client output:**

Running the client application!!

```
EVENT 2: Initialized structure as received in client  
applications:
```

```
1x1 struct array with fields:  
Name  
Address
```

```
Updating the 'Address' field to :
```

```
1x1 struct array with fields:  
Street  
City  
State  
Zip
```

```
#####
```

```
EVENT 5: Final structure as received by client:
```

```
1x1 struct array with fields:  
Name  
Address
```

Address field:

1x1 struct array with fields:

Street

City

State

Zip

#####

## Additional RMI Examples

For more examples of RMI implementation, see the examples in *matlabroot/toolbox/javabuilder/Examples/RMIExamples*.

# Troubleshooting

---

## Common MATLAB Compiler SDK Error Messages

**Exception in thread "main" java.lang.UnsatisfiedLinkError: Failed to find the library mclmcr712.dll, required by MATLAB Compiler SDK, on java.library.path**

Install the MATLAB Runtime or add it to the MATLAB path.

**Failed to find the library <library\_name>, required by MATLAB Compiler SDK, on java.library.path.**

This error commonly occurs on Linux or Mac systems if the LD\_LIBRARY\_PATH variable is not set.

See “MATLAB Runtime Path Settings for Development and Testing” on page 4-2 and “MATLAB Runtime Path Settings for Run-Time Deployment” on page 4-4.

**javac is not recognized as an internal or external command, operable program or batch file.**

This is a common error when the javac executable (javac.exe), installed with Java, is not on your system PATH.

Edit your system environment variables and add your Java installation folder to the PATH variable.



# Reference Information for Java

---

- “Requirements for the MATLAB Compiler SDK Java Target” on page 10-2
- “Data Conversion Rules” on page 10-4
- “Programming Interfaces Generated MATLAB Compiler SDK” on page 10-8
- “Share MATLAB Runtime Instances” on page 10-12
- “MWArray Class Specification” on page 10-13

## Requirements for the MATLAB Compiler SDK Java Target

### In this section...

“System Requirements” on page 10-2

“Path Modifications Required for Accessibility” on page 10-2

“Limitations of the MATLAB Compiler SDK Java Target” on page 10-3

### System Requirements

System requirements and restrictions on use of the MATLAB Compiler SDK Java target are as follows:

- The MATLAB Compiler product must be installed.
- Java Development Kit must be installed.
- Java Runtime Environment that is used by MATLAB and MATLAB Runtime.

**Note:** You should be using the same version of Java that ships with MATLAB. To find out what version of Java MATLAB is running, enter the following MATLAB command:

```
version -java
```

**Caution** MathWorks only supports the Oracle JDK and JRE. A certain measure of

cross-version compatibility resides in the Oracle software and it *may* be possible to run applications with compiled MATLAB functions with non-Oracle JDKs under some circumstances—however, compatibility is not guaranteed.

### Path Modifications Required for Accessibility

In order to use some screen-readers or assistive technologies, such as JAWS, you must add the following DLLs to your Windows path:

```
matlabroot\sys\java\jre\arch\jre\bin\JavaAccessBridge.dll  
matlabroot\sys\java\jre\arch\jre\bin\WindowsAccessBridge.dll
```

You may not be able to use such technologies without doing so.

## **Limitations of the MATLAB Compiler SDK Java Target**

### **MATLAB Java External Interface**

JAR files created by MATLAB Compiler SDK cannot be loaded back into MATLAB with the MATLAB Java External Interface.

### **MATLAB Objects**

The MATLAB Compiler SDK product's Java target does not support MATLAB object data types. MATLAB objects can not "pass" the MATLAB/Java boundary. However, you are free to use objects in your MATLAB code.

## Data Conversion Rules

### In this section...

“Java to MATLAB Conversion” on page 10-4

“MATLAB to Java Conversion” on page 10-5

“Unsupported MATLAB Array Types” on page 10-7

### Java to MATLAB Conversion

The following table lists the data conversion rules for converting Java data types to MATLAB types.

---

**Note:** The conversion rules apply to scalars, vectors, matrices, and multidimensional arrays of the types listed.

The conversion rules apply not only when calling your own methods, but also when calling constructors and factory methods belonging to the `MWArray` classes.

When calling an `MWArray` class method constructor, supplying a specific data type causes the compiler to convert to that type instead of the default.

---

### Java to MATLAB Conversion Rules

Java Type	MATLAB Type
<code>double</code>	<code>double</code>
<code>float</code>	<code>single</code>
<code>byte</code>	<code>int8</code>
<code>int</code>	<code>int32</code>
<code>short</code>	<code>int16</code>
<code>long</code>	<code>int64</code>
<code>char</code>	<code>char</code>
<code>boolean</code>	<code>logical</code>
<code>java.lang.Double</code>	<code>double</code>
<code>java.lang.Float</code>	<code>single</code>

Java Type	MATLAB Type
<code>java.lang.Byte</code>	<code>int8</code>
<code>java.lang.Integer</code>	<code>int32</code>
<code>java.lang.Long</code>	<code>int64</code>
<code>java.lang.Short</code>	<code>int16</code>
<code>java.lang.Number</code>	<code>double</code>
	<b>Note:</b> Subclasses of <code>java.lang.Number</code> not listed above are converted to <code>double</code> .
<code>java.lang.Boolean</code>	<code>logical</code>
<code>java.lang.Character</code>	<code>char</code>
<code>java.lang.String</code>	<code>char</code>
	<b>Note:</b> A Java string is converted to a 1-by-N array of <code>char</code> with N equal to the length of the input string.
	An array of Java strings ( <code>String[]</code> ) is converted to an M-by-N array of <code>char</code> , with M equal to the number of elements in the input array and N equal to the maximum length of any of the strings in the array.
	Higher dimensional arrays of <code>String</code> are converted similarly.
	In general, an N-dimensional array of <code>String</code> is converted to an N+1 dimensional array of <code>char</code> with appropriate zero padding where supplied strings have different lengths.

## MATLAB to Java Conversion

The following table lists the data conversion rules for converting MATLAB data types to Java types.

---

**Note:** The conversion rules apply to scalars, vectors, matrices, and multidimensional arrays of the types listed.

---

## MATLAB to Java Conversion Rules

MATLAB Type	Java Type (Primitive)	Java Type (Object)
cell	Not applicable	Object  <b>Note:</b> Cell arrays are constructed and accessed as arrays of <code>MWArray</code> .
structure	Not applicable	Object  <b>Note:</b> Structure arrays are constructed and accessed as arrays of <code>MWArray</code> .
char	char	<code>java.lang.Character</code>
double	double	<code>java.lang.Double</code>
single	float	<code>java.lang.Float</code>
int8	byte	<code>java.lang.Byte</code>
int16	short	<code>java.lang.Short</code>
int32	int	<code>java.lang.Integer</code>
int64	long	<code>java.lang.Long</code>
uint8	byte	<code>java.lang.Byte</code>  Java has no unsigned type to represent the <code>uint8</code> used in MATLAB. Construction of and access to MATLAB arrays of an unsigned type requires conversion.
uint16	short	<code>java.lang.Short</code>  Java has no unsigned type to represent the <code>uint16</code> used in MATLAB. Construction of and access to MATLAB arrays of an unsigned type requires conversion.
uint32	int	<code>java.lang.Integer</code>  Java has no unsigned type to represent the <code>uint32</code> used in MATLAB. Construction of

MATLAB Type	Java Type (Primitive)	Java Type (Object)
		and access to MATLAB arrays of an unsigned type requires conversion.
uint64	long	java.lang.Long  Java has no unsigned type to represent the uint64 used in MATLAB. Construction of and access to MATLAB arrays of an unsigned type requires conversion.
logical	boolean	java.lang.Boolean
Function handle	Not supported	
Java class	Not supported	
User class	Not supported	

## Unsupported MATLAB Array Types

Java has no unsigned types to represent the uint8, uint16, uint32, and uint64 types used in MATLAB. Construction of and access to MATLAB arrays of an unsigned type requires conversion.

## Programming Interfaces Generated MATLAB Compiler SDK

### In this section...

“APIs Based on MATLAB Function Signatures” on page 10-8

“Standard API” on page 10-9

“mlx API” on page 10-10

“Code Fragment: Signatures Generated for the myprimes Example” on page 10-10

### APIs Based on MATLAB Function Signatures

The compiler generates two kinds of interfaces to handle MATLAB function signatures.

- A *standard* signature in Java

This interface specifies input arguments for each overloaded method as one or more input arguments of class `java.lang.Object` or any subclass (including subclasses of `MWArray`). The standard interface specifies return values, if any, as a subclass of `MWArray`.

- `mlx` API

This interface allows the user to specify the inputs to a function as an `Object` array, where each array element is one input argument. Similarly, the user also gives the `mlx` interface a preallocated `Object` array to hold the outputs of the function. The allocated length of the output array determines the number of desired function outputs.

The `mlx` interface may also be accessed using `java.util.List` containers in place of `Object` arrays for the inputs and outputs. Note that if `List` containers are used, the output `List` passed in must contain a number of elements equal to the desired number of function outputs.

For example, this would be incorrect usage:

```
java.util.List outputs = new ArrayList(3);
myclass.myfunction(outputs, inputs); // outputs 0 elements!
```

And this would be the correct usage:

```
java.util.List outputs = Arrays.asList(new Object[3]);
```



```
myclass.myfunction(outputs, inputs); // list has 3 elements
```

Typically you use the standard interface when you want to call MATLAB functions that return a single array. In other cases you probably need to use the `mlx` interface.

## Standard API

The standard calling interface returns an array of one or more `MWArray` objects.

The standard API for a generic function with none, one, more than one, or a variable number of arguments, is shown in the following table.

Arguments	API to Use
Generic MATLAB function	<code>function [Out1, Out2, ..., varargout] = foo(In1, In2, ..., InN, varargin)</code>
API if there are no input arguments	<code>public Object[] foo(int numArgsOut)</code>
API if there is one input argument	<code>public Object[] foo(int numArgsOut, Object In1)</code>
API if there are two to $N$ input arguments	<code>public Object[] foo( int numArgsOut, Object In1, Object In2, ... Object InN )</code>
API if there are optional arguments, represented by the <code>varargin</code> argument	<code>public Object[] foo( int numArgsOut, Object in1, Object in2, ..., Object InN, Object varargin )</code>

Details about the arguments for these samples of standard signatures are shown in the following table.

Argument	Description	Details About Argument
<code>numArgsOut</code>	Number of outputs	An integer indicating the number of outputs you want the method to return. To return no arguments, omit this argument.

Argument	Description	Details About Argument
		<p>The value of <i>numArgsOut</i> must be less than or equal to the MATLAB function <code>nargout</code>.</p> <p>The <i>numArgsOut</i> argument must always be the first argument in the list.</p>
<i>In1</i> , <i>In2</i> , ... <i>InN</i>	Required input arguments	<p>All arguments that follow <i>numArgsOut</i> in the argument list are inputs to the method being called.</p> <p>Specify all required inputs first. Each required input must be of class <code>MWArray</code> or any class derived from <code>MWArray</code>.</p>
<i>varargin</i>	Optional inputs	<p>You can also specify optional inputs if your MATLAB code uses the <i>varargin</i> input: list the optional inputs, or put them in an <code>Object[]</code> argument, placing the array last in the argument list.</p>
<i>Out1</i> , <i>Out2</i> , ... <i>OutN</i>	Output arguments	<p>With the standard calling interface, all output arguments are returned as an array of <code>MWArrays</code>.</p>

## mlx API

For a function with the following structure:

```
function [Out1, Out2, ..., varargout] = foo(In1, In2, ...,
   InN, varargin)
```

The compiler generates the following API, as the `mlx` interface:

```
public void foo (List outputs, List inputs) throws MWException;
public void foo (Object[] outputs, Object[] inputs)
                throws MWException;
```

## Code Fragment: Signatures Generated for the `myprimes` Example

For a specific example, look at the `myprimes` method. This method has one input argument, so the compiler generates three overloaded methods in Java.

When you add `myprimes` to the class `myclass` and build the class, the compiler generates the `myclass.java` file. A fragment of `myclass.java` is listed to show overloaded implementations of the `myprimes` method in the Java code.

The standard interface specifies inputs to the function within the argument list and outputs as return values. The second implementation demonstrates the `feval` interface, the third implementation shows the interface to be used if there are no input arguments, and the fourth shows the implementation to be used if there is one input argument. Rather than returning function outputs as a return value, the `feval` interface includes both input and output arguments in the argument list. Output arguments are specified first, followed by input arguments.

```
/* mlx interface - List version */
public void myprimes(List lhs, List rhs) throws MWException
{
    (implementation omitted)
}
/* mlx interface - Array version */
public void myprimes(Object[] lhs, Object[] rhs)
                                   throws MWException
{
    (implementation omitted)
}
/* Standard interface - no inputs*/
public Object[] myprimes(int nargout) throws MWException
{
    (implementation omitted)
}
/* Standard interface - one input*/
public Object[] myprimes(int nargout, Object n)
                                   throws MWException
{
    (implementation omitted)
}
```

See “APIs Based on MATLAB Function Signatures” on page 10-8 for details about the interfaces.

## Share MATLAB Runtime Instances

<b>In this section...</b>
“What Is a Singleton MATLAB Runtime?” on page 10-12
“Advantages and Disadvantages of Using a Singleton” on page 10-12

### What Is a Singleton MATLAB Runtime?

You create an instance of the MATLAB Runtime that can be shared among all subsequent class instances within a component. This is commonly called a shared runtime instance or a *Singleton runtime*.

### Advantages and Disadvantages of Using a Singleton

In most cases, a singleton runtime will provide many more advantages than disadvantages. Following are examples of when you might and might not create a shared MATLAB Runtime instance.

#### When You Should Use a Singleton

If you have multiple users running from a specific instance of MATLAB, using a singleton will most likely:

- Utilize system memory more efficiently
- Decrease MATLAB Runtime start-up or initialization time

#### When You Might Avoid Using a Singleton

Using a singleton may not benefit you if your application uses a large number of global variables. This causes crosstalk.

## MWArray Class Specification

For complete reference information about the MWArray class hierarchy, see `com.mathworks.toolbox.javabuilder.MWArray`, which is in the *matlabroot*/help/toolbox/javabuilder/MWArrayAPI/ folder.

---

**Note:** For *matlabroot*, substitute the MATLAB root folder on your system. Type `matlabroot` to see this folder name.

---



# Functions — Alphabetical List

---

## mcrinstaller

Display version and location information for MATLAB Runtime installer corresponding to current platform

### Syntax

```
[INSTALLER_PATH, MAJOR, MINOR, PLATFORM, LIST] = mcrinstaller;
```

### Description

Displays information about available MATLAB Runtime installers using the format: `[INSTALLER_PATH, MAJOR, MINOR, PLATFORM, LIST] = mcrinstaller;` where:

- *INSTALLER\_PATH* is the full path to the installer for the current platform.
- *MAJOR* is the major version number of the installer.
- *MINOR* is the minor version number of the installer.
- *PLATFORM* is the name of the current platform (returned by `COMPUTER(arch)`).
- *LIST* is a cell array of strings containing the full paths to MATLAB Runtime installers for other platforms. This list is non-empty only in a multi-platform MATLAB installation.

---

**Note:** You must distribute the MATLAB runtime library to your end users to enable them to run applications developed with MATLAB Compiler or MATLAB Compiler SDK.

---

See “Install the MATLAB Runtime” on page 3-6 for more information about the MATLAB Runtime installer.

### Examples

#### Find MATLAB Runtime Installer Locations

Display locations of MATLAB Runtime installers for platform. This example shows output for a win64 system.



**mcrinstaller**

The WIN64 MCR Installer, version 7.16, is:

```
X:\jobx\clusterc\current\matlab\toolbox\compiler\  
    deploy\win64\MCRInstaller.exe
```

MCR installers for other platforms are located in:

```
X:\jobx\clusterc\current\matlab\toolbox\compiler\  
    deploy\win64
```

win64 is the value of COMPUTER(win64) on  
the target machine.

For more information, read your local MCR Installer help.

Or see the online documentation at MathWorks' web site. (Page  
may load slowly.)

ans =

```
X:\jobx\clusterc\current\matlab\toolbox\compiler\  
    deploy\win64\MCRInstaller.exe
```

## mcrversion

Determine version of installed MATLAB Runtime

### Syntax

```
[major, minor] = mcrversion;
```

### Description

The MATLAB Runtime version number consists of two digits, separated by a decimal point. This function returns each digit as a separate output variable: `[major, minor] = mcrversion;` Major and minor are returned as integers.

If the version number ever increases to three or more digits, call `mcrversion` with more outputs, as follows:

```
[major, minor, point] = mcrversion;
```

At this time, all outputs past “minor” are returned as zeros.

Typing only `mcrversion` will return the major version number only.

### Examples

```
mcrversion  
ans =  
    7
```

## waitForFigures

Block execution of a calling program as long as figures created in encapsulated MATLAB code are displayed

### Syntax

```
objName.waitForFigures();
```

### Description

`waitForFigures()` blocks execution of a calling program as long as figures created in encapsulated MATLAB code are displayed. Typically you use `waitForFigures` when:

- There are one or more figures open that were created by a Java class created by the MATLAB Compiler SDK product.
- The method that displays the graphics requires user input before continuing.
- The method that calls the figures was called from `main()` in a console program.

When `waitForFigures` is called, execution of the calling program is blocked if any figures created by the calling object remain open.

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**Caution** Use care when calling the `waitForFigures` method. Calling this method from an interactive program like Microsoft<sup>®</sup> Excel<sup>®</sup> can hang the application. Call this method *only* from console-based programs.

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### Related Examples

- “Block Execution of Applications that Creates Figures” on page 2-52

**Introduced before R2006a**

