MATLAB® Builder for .NET

The Language of Technical Computing

- Computation
- Visualization
- Programming

User's Guide

Version 2

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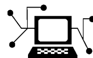

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MATLAB Builder for .NET User's Guide

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Glossary

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1

Getting Started

This chapter provides a quick start for using MATLAB® Builder for .NET. See later chapters for more details.

What Is MATLAB Builder for .NET? (p. 1-2)	Brief description of what the product does and how it works
Creating a .NET Component (p. 1-4)	Step-by-step procedure to create and package a MATLAB Builder for .NET component that encapsulates MATLAB code
Using Components Created with MATLAB Builder for .NET (p. 1-9)	Step-by-step procedure to access a MATLAB Builder for .NET component in an application
Magic Square Example (p. 1-10)	Step-by-step example, including code for a simple MATLAB function and a simple .NET application written in C#

What Is MATLAB Builder for .NET?

MATLAB Builder for .NET (also called .NET Builder) is an extension to the MATLAB Compiler. Use MATLAB Builder for .NET to package MATLAB functions so that .NET programmers can access them from any *CLS-compliant language*.

Note CLS is an acronym for *Common Language Specification*. CLS is a subset of language features supported by the *.NET common language runtime (CLR)*. CLS includes features common to several object-oriented programming languages, such as C#, VB.NET, and C++ with managed extensions. CLS-compliant components and tools are guaranteed to interoperate with other CLS-compliant components and tools.

When you package and distribute the application to your users, you must include supporting files generated by .NET Builder as well as the MATLAB Component Runtime (MCR).

How Does .NET Builder Work?

.NET Builder converts MATLAB functions to .NET methods that encapsulate the MATLAB code. Each .NET Builder component contains one or more classes, and each class provides an interface to the M-functions that you add to the class at build time. The .NET component provides a set of CLS-compliant methods that wrap the M-code.

.NET Builder provides robust data conversion, indexing, and array formatting capabilities to preserve the flexibility of MATLAB when called from managed code. To support the MATLAB data types, .NET Builder provides the `MWArray` class hierarchy, which is defined in the .NET Builder `MWArray` assembly. You need to reference this assembly in your managed application to convert native arrays to MATLAB arrays and vice versa.

.NET Builder also provides custom error handling so that errors originating from MATLAB functions are reported as standard managed exceptions. The error description contains specific references to the MATLAB code, thus simplifying the debugging process.

Creating COM Components

You can also use .NET Builder to create COM components. COM stands for Component Object Model, which is a software architecture developed by Microsoft to build component-based applications. COM objects expose interfaces that allow applications and other components to access the features of the objects. COM objects are accessible through Visual Basic, C++, or any language that supports COM objects. See Chapter 9, "Creating a COM Component" and Chapter 10, "Programming with COM Components Created by MATLAB Builder for .NET" for more information about creating and accessing COM components.

Known Issue in Data Returned by ToArray Referencing Sparse Format

There is a known issue where the data returned by calling `ToArray` on a `MWNumericArray` or `MWLogicalArray` object that references a MATLAB array stored in sparse format may be incorrect or corrupted. If this use case applies to your work, see "Version 2.1 (R2006b) MATLAB Builder for .NET" in the Release Notes for a link to information and a patch to fix this problem.

Creating a .NET Component

To create a component you need to write M-code (or use existing code) and then create a project in MATLAB Builder for .NET that encapsulates the code. This section describes how to create a .NET component using the Deployment Tool. For information about using the `mcc` command to create a component, see "Using the Command Line to Create .NET Components" on page 1-5.

1. Write, test, and save the MATLAB code to be used as the basis for the .NET component.

2. While you are still in MATLAB, issue the following command:

   ```
   deploytool
   ```

   The Deployment Tool dialog box opens.

3. Create a new project by clicking the New Project button in the toolbar.

4. Add files that you want to encapsulate by dragging them to the Deployment Tool, or by selecting them and clicking the Add Files button in the toolbar.

5. Set properties for building and packaging. Click **Settings** or click the Settings button in the toolbar. You can use the Settings dialog box to specify many build and packing options, such as building a debug version of your compiled models and specifying verbose output. Use the .NET page in the Settings dialog box to create a shared assembly or specify the version of the .NET framework you want your component to work with.

6. Save the project by clicking the Save button in the toolbar.

7. Build the component. Click the Build button in the toolbar to start the build process.

   The build process generates C# code for the wrapper class in the `\src` subdirectory of your project directory. It also creates a component assembly containing the wrapper class and a `component.ctf` file in the `\distrib` subdirectory of your project directory. The files in the `\distrib` directory define your .NET component.

The `.ctf` is a component technology file, which is required to support components that encapsulate MATLAB functions when running them on a user machine that does not have the MATLAB desktop installed.

The **Output** pane shows the output of the build process and informs you of any problems encountered. The resulting DLL is automatically registered on your system.

8. Test, edit, and rebuild the component as needed.

   You probably want to test your component before using it in an application or before packaging it for use by others. After testing the component on your development platform, you can reopen the project if necessary and proceed to the next step.

9. Optionally, create a self-extracting executable containing the files that are required for application development using the generated component. You can do this by clicking the Package button in the toolbar.

   Optionally include the MATLAB Component Runtime (MCR) if necessary.

   Note The packaging step is necessary only if you want to make the component available to other application developers on another machine.

   ---

10. Distribute and run the self-extracting executable on the development machine.

Using the Command Line to Create .NET Components

Instead of using the Deployment Tool to create .NET components, you can use the `mcc` command.

The following sections describe the subset of `mcc` command options that are required to create .NET components. The sections provide detailed `mcc` syntax with examples.

- "Command-Line Syntax Description" on page 1-6

- “Using the .NET Bundle Files to Simplify the Command” on page 1-7
- “Example: Creating a .NET Component Namespace” on page 1-8
- “Example: Adding Multiple Classes to a Component” on page 1-8

To learn more about the mcc command and all of its options, see the MATLAB Compiler documentation.

Note If you use mcc to create .NET components, you do not need to create a project.

Command-Line Syntax Description

The following defines the complete mcc command syntax with all required and optional arguments to create a .NET component. Brackets indicate optional parts of the syntax.

```
mcc  -W 'dotnet:component_name,class_name,
0.0|1.1|2.0, Private|Encryption_Key_Path' file1
[file2...fileN][class{class_name:file1 [,file2,...,fileN]},... [-d
output_dir_path] -T link:lib
```

The following explains each part of this syntax.

-W

Tells the compiler to create a wrapper function. This option takes a string argument that specifies the following characteristics of the component.

-W String Elements	Description
dotnet:	Keyword that tells the compiler the type of component to create, followed by a colon. Specify dotnet to create a .NET component.
component_name	Specifies the name of the component and its namespace, which is a period-separated list, such as companyname.groupname.component.

-W String Elements	Description
`class_name`	Specifies the name of the .NET class to be created.
`0.0|1.1|2.0`	Specifies the version of the .NET framework you want to use to compile the component. You can specify one of three values: `0.0` — Use latest supported version on the target machine `1.1` — Use Version 1.1 of the framework `2.0` — Use Version 2.0 of the framework
`Private|Encryption_Key_Path`	Specifies whether the component to be created is a private assembly or a shared assembly. To create a shared assembly, you must specify the full path to the encryption key file used to sign the assembly.

`file1 [file2...fileN]`
: Specifies the M-file or M-files that are to be encapsulated as methods in the class being created (`class_name`).

`class{class_name:file1 [,file2,...,fileN]},...`
: (Optional) Specifies additional classes that you want to include in the component. To use this option, you specify the class name, followed by a colon, and then the names of the files you want to include in the class. You can include this multiple times to specify multiple classes.

`[-d output_dir_path]`
: (Optional) Tells .NET Builder to create a directory and copy the output files to it. If you use `mcc` instead of the Deployment Tool, the *project_directory*`\src` and *project_directory*`\distrib` directories are not automatically created.

`-T`
: Specifies the output type. To create a .NET component, specify the keyword `link:lib`, which links objects into a shared library (DLL).

Using the .NET Bundle Files to Simplify the Command

To simplify the command line used to create .NET components, you can use the .NET Builder bundle file, named `dotnet`, to make creating .NET components easier. When using this bundle file, you must still pass in the four parts of the `-W` argument text string, however you do not have to specify the `-T` option.

The following example creates a .NET component called mycomponent containing a single .NET class named myclass with methods foo and bar. When used with the -B option, the word *dotnet* specifies the name of the predefined .NET Builder bundle file.

```
mcc -B 'dotnet:mycomponent,myclass,2.0,encryption_keyfile_path'
 foo.m bar.m
```

In this example, .NET Builder uses the .NET Framework version 2.0 to compile the component into a shared assembly using the key file specified in encryption_keyfile_path to sign the shared component.

Example: Creating a .NET Component Namespace

The following example creates a .NET component from two M-files, foo.m and bar.m.

```
mcc  -B 'dotnet:com.mycompany.mycomponent,myclass,0.0,Private'
 foo.m bar.m
```

The example creates a .NET component named mycomponent that has the following namespace: com.mycompany. The component contains a single .NET class, myclass, which contains methods foo and bar.

To use myclass place the following statement in your code:

```
using com.mycompany.mycomponent;
```

Example: Adding Multiple Classes to a Component

The following examples creates a .NET component that includes more than one class. This example uses the optional class{...} argument to the mcc command.

```
mcc  -B 'dotnet:com.mycompany.mycomponent,myclass,2.0,Private' foo.m bar.m
class{myclass2:foo2.m,bar2.m}
```

The example creates a .NET component named mycomponent with two classes:

myclass has methods foo and bar

myclass2 has methods foo2 and bar2

Using Components Created with MATLAB Builder for .NET

This section describes how to use a component created with the MATLAB Builder for .NET in a .NET application.

1. If the component is not already installed on the machine where you want to develop your application, run the self-extracting executable that was created in "Creating a .NET Component" on page 1-4. This step is not necessary if you are developing your application on the same machine where you created the .NET component.

2. Reference the .NET component in your Visual Studio project or from the command line of a CLS-compliant compiler.)

   You must also add a reference to the `MWArray` component, *`matlabroot`*`\bin\win32\MWArray.dll.`

3. Instantiate the MATLAB Builder for .NET classes and call the class methods as you would with any .NET class. To marshal data between the native .NET types and the MATLAB array type, you need to use the MWArray data conversion classes. See "Overview of Classes" on page 7-12 for an introduction to the classes and see MWArray Class Library Reference (available online only) for details about the API for this class library.

4. Build and test the .NET application as you would any application.

5. Create an application installation package for end users that includes the files required for the .NET Builder components that encapsulate the MATLAB functions.

Magic Square Example

The Magic Square example shows you how to create a .NET component that encapsulates a MATLAB function, `makesquare`. The component computes a magic square. The example then shows how to use this component in a sample application, called `MagicSquareApp.cs`. The sample application displays the array returned by the `makesquare` method, using the MWarray conversion classes to convert the array to a native array. When you run the `MagicDemoApp` application from the command line, you can pass the dimension for the magic square as a command-line argument.

The following sections provide step-by-step instructions for building and running the example.

Building the .NET Component

1. Copy the files for this example from the appropriate .NET Builder examples directory into your work directory. There are example directories for Version 7 (`VS7`) and Version 8 (`VS8`) of Microsoft Visual Studio .NET. The example copies the files from the `VS7` directory. The example assumes your work directory is `D:\Work`.

   ```
   matlabroot\toolbox\dotnetbuilder\Examples\VS7\MagicSquareExample
   ```

   `matlabroot` represents the name of your top-level MATLAB installation directory, as returned by the `matlabroot` command.

   Note If you have Microsoft Visual Studio .NET installed, you can load projects for all the examples by opening either `DotNetExamples.sln`. Be sure to copy the solution for the version of Visual Studio .NET that you are using, Version 7 or Version 8.

   ---

2. At the MATLAB command prompt, change directory to the new `MagicSquareExample` subdirectory in your work directory.

3. Write the `makesquare` function as you would any MATLAB function.

   Here is the code for the `makesquare` function:

```
function y = makesquare(x)
  y = magic(x);
```

This code is already in your directory in `MagicSquareExample\MagicDemoComp\makesquare.m`.

4 Create a .NET component as follows:

a. While in MATLAB, issue the following command to open the Deployment Tool:

```
deploytool
```

b. Create a new project by clicking the New Project button in the toolbar.

c. Specify the following settings for your project. Click the Settings button to open the Settings dialog box.

Setting	Value
Component name	`MagicDemoComp`
Class name	`MagicSquare`
Project directory	The name of your work directory followed by the project name. In this example, that is `D:\Work\MagicSquareExample\MagicDemoComp`.
Show verbose output	Selected

d. Add the `makesquare.m` file to the project. Locate your work directory and navigate to the `MagicDemoComp` directory, which contains the M-file for the `makesquare` function.

5 Build the component by clicking the Build button in the Deployment Tool toolbar.

The build process begins, and a log of the build appears in the **Output** pane of the Deployment Tool dialog box. The files that are needed for the component are generated in two newly created directories, `src` and

distrib, in the MagicDemoComp directory. A copy of the build log is placed in the src directory.

See “What Happens in the Build Process?” on page 2-7 for more information.

Using the Component in an Application

1 Write source code for an application that uses the .NET component created in “Building the .NET Component” on page 1-10.

   The C# source code for the sample application for this example is in MagicSquareExample\MagicDemoCSharpApp\MagicDemoApp.cs.

   The program listing is shown here.

Note Although .NET Builder generates C# code for the MagicSquare component and the sample application is in C#, applications that use the component do not need to be coded in C#. You can access the component from any CLS-compliant .NET language. For examples, see Chapter 5, “Sample Applications (Visual Basic)”.

MagicDemoApp.cs

```
// *******************************************************************************
//
// MagicDemoApp.cs
//
// This file is an example application for the MATLAB Builder for .NET product.
//
// Copyright 2001-2005 The MathWorks, Inc.
//
// *******************************************************************************

using System;

using MathWorks.MATLAB.NET.Utility;
using MathWorks.MATLAB.NET.Arrays;
```

```
using MagicDemoComp;


namespace MathWorks.Demo.MagicSquareApp
{
 /// <summary>
 /// The MagicSquareApp demo class computes a magic square of the user specified size.
 /// </summary>
 /// <remarks>
 /// args[0] - a positive integer representing the array size.
 /// </remarks>
 class MagicDemoApp
   {
      #region MAIN

    /// <summary>
    /// The main entry point for the application.
    /// </summary>
    [STAThread]
    static void Main(string[] args)
      {
          MWNumericArray arraySize= null;
          MWNumericArray magicSquare= null;

          try
            {
              // Get user specified command line arguments or set default
               arraySize= (0 != args.Length) ? System.Double.Parse(args[0]) : 4;

              // Create the magic square object
              MagicSquare magic= new MagicSquare();

              // Compute the magic square and print the result
              magicSquare= (MWNumericArray)magic.makesquare((MWArray)arraySize);

              Console.WriteLine("Magic square of order {0}\n\n{1}", arraySize, magicSquare);

              // Convert the magic square array to a two dimensional native double array
              double[,] nativeArray= (double[,])magicSquare.ToArray(MWArrayComponent.Real);
```

```
            Console.WriteLine("\nMagic square as native array:\n");

            // Display the array elements:
            for (int i= 0; i < (int)arraySize; i++)
              for (int j= 0; j < (int)arraySize; j++)
                Console.WriteLine("Element({0},{1})= {2}", i, j, nativeArray[i,j]);

            Console.ReadLine();  // Wait for user to exit application
          }

        catch(Exception exception)
          {
            Console.WriteLine("Error: {0}", exception);
          }
}
```

2 Build the application using Visual Studio .NET.

a. Open the project file for the Magic Square example (`MagicDemoCSharpApp.csproj`) in Visual Studio .NET.

b. If necessary, add a reference to the `MWArray` component, which is *`matlabroot`*`\bin\win32\MWArray.dll`.

c. If necessary, add a reference to the Magic Square component (`MagicDemoComp`), which is the `distrib` subdirectory.

d. Build and run the application in Visual Studio .NET.

   The first time you run the application, Visual Studio .NET creates a directory named `MagicDemo_MCR` in `MagicSquareExample\bin\debug`. The `MagicDemo_MCR` directory contains encrypted versions of M-files that the application requires.

2

Building and Packaging a .NET Component

To build a .NET component, you must first create a project, which specifies the M-code to be used in the component that you want to create. This section describes the elements of a .NET Builder project. In addition, this section describes the data conversion between managed types and MATLAB types that is supported by .NET Builder.

Elements of a MATLAB Builder for .NET Project (p. 2-2)	How MATLAB Builder for .NET uses the specifications in a project
How Does MATLAB Builder for .NET Handle Data? (p. 2-4)	How MATLAB Builder for .NET supports data conversion between managed types and MATLAB types
What Happens in the Build Process? (p. 2-7)	Details about the process of building a .NET component
What Happens in the Package Process? (p. 2-9)	Details about the packaging process
How Does Component Deployment Work? (p. 2-10)	Details about deploying to an end user

Elements of a MATLAB Builder for .NET Project

A .NET Builder project contains the files and settings needed by MATLAB Builder for .NET to create a deployable .NET component. A project specifies information about classes and methods, including the MATLAB functions to be included.

- "Classes and Methods" on page 2-2
- "Component and Class Naming Conventions" on page 2-2
- "Versions" on page 2-3

Classes and Methods

.NET Builder transforms MATLAB functions that are specified in the component's project to methods belonging to a *managed class*.

When creating a component, you must provide one or more class names as well as a component name. The component name also specifies the name of the assembly that implements the component. The class name denotes the name of the class that encapsulates MATLAB functions.

To access the features and operations provided by the MATLAB functions, instantiate the managed class generated by .NET Builder, and then call the methods that encapsulate the MATLAB functions.

Component and Class Naming Conventions

Typically you should specify names for components and classes that will be clear to programmers who use your components. For example, if you are encapsulating many MATLAB functions, it helps to determine a scheme of function categories and to create a separate class for each category. Also, the name of each class should be descriptive of what the class does.

The *.NET Framework General Reference* recommends the use of *Pascal case* for capitalizing the names of identifiers of three or more characters. That is, the first letter in the identifier and the first letter of each subsequent concatenated word are capitalized. For example:

```
MakeSquare
```

In contrast, MATLAB programmers typically use all lowercase for names of functions. For example:

```
makesquare
```

By convention, MATLAB Builder for .NET examples use Pascal case.

Versions

.NET Builder supports the standard versioning capabilities provided by the .NET framework.

You can make side-by-side invocations of multiple versions of a component within the same application only if they access the same version of the MCR.

How Does MATLAB Builder for .NET Handle Data?

- “MATLAB Function Signatures” on page 2-4
- “Understanding Data Conversion Classes” on page 2-4
- “Automatic Casting to MATLAB Types” on page 2-6

MATLAB Function Signatures

MATLAB supports multiple signatures for function calls.

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.

All arguments represent a specific MATLAB type.

When MATLAB Builder for .NET processes your M-code, it creates several overloaded methods that implement the MATLAB functions. Each of these overloaded methods corresponds to a call to the generic MATLAB function with a specific number of input arguments. In addition to these methods, .NET Builder creates another method that defines the return values of the MATLAB function as input arguments. This method simulates the `feval` external API interface in MATLAB.

Understanding Data Conversion Classes

To support data conversion between managed types and MATLAB types, .NET Builder provides a set of data conversion classes derived from the abstract class, `MWArray`.

When you invoke a method on a .NET Builder component, the input and output parameters are a derived type of `MWArray`. To pass parameters, you can either instantiate one of the `MWArray` subclasses explicitly, or, in many

cases, pass the parameters as *managed data types* and rely on implicit data conversion.

Overview of Classes and Methods in the Data Conversion Class Hierarchy

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

Note See "Overview of Classes" on page 7-12 for an introduction to the classes and see MWArray Class Library Reference (available online only) for details about this class library.

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

`MWArray` and the classes derived from `MWArray` provide the following:

- Constructors and destructors to instantiate and dispose of MATLAB arrays
- Properties to get and set the array data
- Indexers to support a subset of MATLAB array indexing
- Implicit and explicit data conversion operators
- General methods

Advantage of Using Data Conversion Classes

The `MWArray` data conversion classes allow you to pass native .NET types as parameters directly without using explicit data conversion. There is an implicit cast operator for most native numeric and string types that will convert the native type to a MATLAB array.

Automatic Casting 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 Builder for .NET components.

In most instances, if a native .NET primitive or array is used as an input parameter in a C# program, .NET Builder transparently converts it to an instance of the appropriate `MWArray` class before it is passed on to the method. .NET Builder can convert most CLS-compliant string, numeric type, or multidimensional array of these types to an appropriate `MWArray` type.

Note This conversion is transparent in C# applications, but might require an explicit casting operator in other languages, for example, `op_implicit` in Visual Basic.

Here is an example. Consider the .NET statement:

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

In this statement the third argument, namely `interval`, is of the .NET native type `System.Double`. .NET Builder casts this argument to a MATLAB 1-by-1 double `MWNumericArray` type (which is a wrapper class containing a MATLAB double array).

See "Data Conversion Rules " on page 7-9 for a list of all the data types that are supported along with their equivalent types in MATLAB.

Note There are some data types commonly used in MATLAB that are not available as native .NET types. Examples are cell arrays, structure arrays, and arrays of complex numbers. Represent these array types as instances of `MWCellArray`, `MWStructArray`, and `MWNumericArray`, respectively.

What Happens in the Build Process?

To create a component, .NET Builder does the following:

1. Generates C# code to implement your component

   The first step of the build process generates two C# files: a component data file and a component wrapper. The component data file contains static information for the component. The wrapper contains the implementation code for the .NET component and provides a .NET application programming interface (API) for the MATLAB functions you add to the project at design time.

2. Compiles the C# code and generates `/distrib` and `/src` subdirectories

   The second step of the build process invokes the C# compiler on the files produced in step 1, creating a managed assembly file for the component.

   .NET Builder creates two subdirectories under the project directory: *`project-directory`*`/src` and *`project-directory`*`/distrib`. These subdirectories contain the following files:

   Files in the Project Subdirectories

Subdirectory	Files	Description
`src`	*`ComponentName`* `_mcc_component_data.cs`	C# component data file
	`ClassName1``.cs ...` *`ClassNameN`*`.cs`	C# wrapper class file

Files in the Project Subdirectories (Continued)

Subdirectory	Files	Description
distrib	*ComponentName*.dll	.NET component assembly
	ComponentName.ctf	Component CTF file
	ComponentName.pdb	.NET component debug file (Debug builds only)
	ComponentName.xml	.NET component XML documentation file

Note When you build your project, you can specify the compilation of a private or shared assembly. A private assembly is copied to an application subdirectory and is owned exclusively by the application. A shared assembly usually resides in the Global Assembly Cache, and can be directly referenced by multiple applications.

How the MCR Is Shared Among Classes

.NET Builder creates a single MCR instance for each .NET Builder component in an application. This MCR is reused and shared among all subsequent class instances within the component, resulting in more efficient memory usage and eliminating the MCR startup cost in each subsequent class instantiation. All class instances share a single MATLAB workspace and share global variables in the M-files used to build the component.

The following example creates a .NET component called `mycomponent` containing a single .NET class named `myclass` with methods `foo` and `bar`.

If and when multiple instances of `myclass` are instantiated in an application, only one MCR is initialized, and it is shared by all instances of `myclass`.

```
mcc -B 'dotnet:mycomponent,myclass,1.1,Private' foo.m bar.m
```

What Happens in the Package Process?

The package process zips the following files into a single self-extracting executable, `componentName.exe`:

- *`componentName`*`.dll`
- *`componentName`*`.ctf`
- *`componentName`*`.xml`
- *`componentName`*`.pdb` (if **Debug** option is selected)
- `MCRInstaller.exe` (if **Include MCR** option is selected)
- `_install.bat` (Script run by the self-extracting executable)

How Does Component Deployment Work?

To deploy the component, run the component installer. If the MCR is not already installed, and if the **Install MCR** option was selected, the component installer does the following:

1. Installs the MCR (if not already installed on the target machine).
2. Installs the component assembly in the directory from which the installer is run
3. Copies the `MWArray` assembly to the Global Assembly Cache (GAC), as part of installing the MCR

Note On target machines where the MCR Installer is run, the MCR Installer puts the `MWArray` assembly in *`installdir`*`\V75\runtime\win32`, where *`installdir`* is the target directory for the MCR.

The MCR Installer uses a standard Microsoft installation file that provides the following features:

- Integrates with `Add/Remove Programs` in the Control Panel
- Checks software prerequisites before installation
- Checks for proper user permissions
- Rolls back the system to its prior state on installation failure
- Supports component versioning

3

Using Components Created by MATLAB Builder for .NET

To use a .NET component built and packaged by MATLAB .NET Builder, perform the following tasks.

Installing the Components on the Development Machine (p. 3-2)	How to unpack and install the components so you can use them on a particular machine
Specifying Component Assembly and Namespace (p. 3-3)	How to specify the assembly and namespace
Creating an Instance of the Class (p. 3-4)	Sample code for instantiating a class that encapsulates MATLAB code
Converting Native Data Types to MATLAB Data Types (p. 3-5)	How to specify types and use `MWArray` to handle arguments
Handling Errors (p. 3-14)	How to handle an error generated by MATLAB
Managing Native Resources (p. 3-16)	How to free memory used by the `MWArray` data conversion classes

Installing the Components on the Development Machine

To use components on a particular development machine:

1. Unpack and install the components on the machine.
2. Copy *packagename*.exe to a directory on the development machine, and run it.

You must repeat these steps for each machine where the component will be used.

Specifying Component Assembly and Namespace

To use the component assembly generated using MATLAB Builder for .NET, you must

- Reference the namespace for the MATLAB data conversion assembly, as shown:

  ```
  using MathWorks.MATLAB.Arrays;
  ```

- Reference the namespace for the .NET Builder assembly generated for your particular component, for example:

  ```
  using MyComponentName;
  ```

Note .NET Builder supports nested namespaces.

Suppose you named the component you created `MyComponentName` and you want to use it in a program named `MyApp.cs`. Here are the statements to use at the beginning of `MyApp.cs`:

```
using System;
using MathWorks.MATLAB.Arrays;
using MyComponentName;
```

Note .NET Builder supports shared assemblies. To build your component as a shared assembly, click the Settings button in the Deployment Tool toolbar, and select `.NET` in the navigation pane. On the .NET page, select **public**. Alternatively, you can use the `mcc -B` option with the `dotnet` bundle; see “Using the Command Line to Create .NET Components” on page 1-5.

Creating an Instance of the Class

As with any .NET class, you need to instantiate the classes you create with MATLAB Builder for .NET before you can use them in your program.

Suppose you build a component with a class named `MyComponentClass`. Here is an example of creating an instance of that class.

```
MyComponentClass classInstance = new MyComponentName();
```

See "How the MCR Is Shared Among Classes" on page 2-8 for information about what happens when you instantiate classes.

Converting Native Data Types to MATLAB Data Types

The call signature for a method based on a MATLAB function uses one of the MATLAB data conversion classes to pass arguments and return output.

This example explicitly creates a numeric constant using the constructor for the `MWNumericArray` class with a `System.Int32` argument.

```
int data = 24;
MWNumericArray array = new MWnumericArray(data);
Console.WriteLine("Array is of type " + array.NumericType);
```

When you run this example, the results are

```
Array is of type double
```

In this example, the native integer (`int data`) is converted to an `MWNumericArray` containing a 1-by-1 MATLAB double array, which is the default MATLAB type.

Note To preserve the integer type (rather than convert to the default double type), you can use the constructor provided by `MWNumericArray` for this purpose. Preserving the integer type can help to save space.

MATLAB Builder for .NET does not support some MATLAB array types because they are not CLS-compliant. See “Unsupported MATLAB Array Types” on page 7-11 for a list of the unsupported types.

The following topics provide more information about data conversion.

- “Specifying the Type” on page 3-6
- “Specifying Optional Arguments” on page 3-6
- “Handling MATLAB Global Variables” on page 3-9
- “Handling Return Values” on page 3-9

For more information about the concepts involved in data conversion, see “How Does MATLAB Builder for .NET Handle Data?” on page 2-4.

Specifying the Type

If you want to create a MATLAB numeric array of a specific type, set the optional makeDouble argument to False. The native type then determines the type of the MATLAB array that is created.

Here, the code specifies that the array should be constructed as a MATLAB 1-by-1 16-bit integer array:

```
short data = 24;
MWNumericArray array = new MWnumericArray(data, False);
Console.WriteLine("Array is of type " + array.NumericType);
```

Running this example produces the following results:

```
Array is of type int16
```

Specifying Optional Arguments

In MATLAB, varargin and varargout are used to specify arguments that are not required. Consider the following M-function:

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

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

For the mysum function, .NET Builder generates the following interfaces:

```
// Single output interfaces
public MWArray mysum()
public MWArray mysum(params MWArray[] varargin)
// Standard interface
public MWArray[] mysum(int numArgsOut)
public MWArray[] mysum(int numArgsOut, params MWArray[] varargin)
// feval interface
public void mysum(int numArgsOut, ref MWArray ArgsOut,
      params MWArray[] varargin)
```

The varargin arguments can be passed as either an MWArray[], or as a list of explicit input arguments. (In C#, the params modifier for a method argument specifies that a method accepts any number of parameters of the specific type.) Using params allows your code to add any number of optional inputs to the encapsulated M-function.

Here is an example of how you might use the mysum method in a .NET application:

```
[STAThread]
static void Main(string[] args]
{
MWArray sum= null;
MySumClass mySumClass = null;
try
  {
   mySumClass= new MySumClass();
   sum= mySumClass.mysum((double)2, 4);
   Console.WriteLine("Sum= {0}", sum);
   sum= mySumClass.mysum((double)2, 4, 6, 8);
   Console.WriteLine("Sum= {0}", sum);
  }
}
```

The number of input arguments can vary.

Note Note that for this signature you must explicitly cast the first argument to a double to distinguish the signature from the method signature that takes an integer as the first argument (where the first argument specifies the number of output arguments).

Examples of Passing Input Arguments

The following examples show generated code for the myprimes M-function, which has the following definition:

```
function p = myprimes(n)
```

Construct a Single Input Argument. The following sample code constructs data as a MWNumericArray, to be passed as input argument:

```
MWNumericArray data = 5;
MyPrimesClass myClass = new MyPrimesClass();
MWArray primes = myClass.myPrimes(data);
```

Pass a Native .NET Type. This example passes a native double type to the function.

```
MyPrimesClass myClass = new MyPrimesClass();
MWArray primes = myClass.myPrimes((double)13));
```

The input argument is converted to a MATLAB 1-by-1 double array, as required by the M-function. This is the default conversion rule for a native double type (see "Data Conversion Rules " on page 7-9 for a discussion of the default data conversion for all supported .NET types).

Use the feval Interface. This interface passes both input and output arguments on the right-hand side of the function call. The output argument primes must be preceded by a ref attribute.

```
MyPrimesClass myClass = new MyPrimesClass();
MWNumericArray maxPrimes = 13;
MWArray primes = null;
myClass.myPrimes(1, ref primes, maxPrimes);
```

Passing Array Inputs

The next example implements a more general method that takes an array of .NET numeric primitives and converts each to an MWNumericArray that is then passed to the mySum function (see "Specifying Optional Arguments" on page 3-6 for the listing of mysum).

```
public double getsum(int[] argsIn)
{
MWArray sum= null;
MWArray[] argsInArray;
MySumClass mySumClass= null;
try
  {
```

```
    argsInArray= new MWArray[argsIn.Length];
    for (int idx= 0; idx <argsIn.Length; idx++)
    {
       argsInArray[idx]= new MWNumericArray((double)argsIn[idx]);
    }
     mySumClass= new MySumClass();
     sum= mySumClass.mysum(argsInArray);
     return (double)sum;
   }
 }
```

Passing a Variable Number of Outputs

When present, `varargout` arguments are handled in the same way that `varargin` arguments are handled. Consider the following M-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`. .NET Builder generates a .NET interface to this function as follows:

```
public void randvectors()
public MWArray[] randvectors(int numArgsOut)
public void randvectors(int numArgsOut, ref MWArray[] varargout)
```

Handling MATLAB Global Variables

When programming with .NET Builder components, you should be aware that each component is associated with a separate instance of the MCR. This means that you should avoid using global variables that cross over from one component to another.

Handling Return Values

The previous examples show guidelines to use if you know the type and dimensionality of the output argument. Sometimes, in MATLAB programming, this information is unknown, or can vary. In this case, the code

that calls the method might need to query the type and dimensionality of the output arguments.

There are two ways to make the query; you can either

- Use .NET reflection to query any object for its type.
- Use any of several methods provided by the `MWArray` class to query information about the underlying MATLAB array.

Use .NET Reflection

You can use *reflection* to dynamically create an instance of a type, bind the type to an existing object, or get the type from an existing object. You can then invoke the type's methods or access its fields and properties. See the MSDN Library for more information about reflection.

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

```
public void GetPrimes(int n)
{
 MWArray primes= null;
 MyPrimesClass myPrimesClass= null;
 try
  {
  myPrimesClass= new MyPrimesClass();
  primes= myPrimesClass.myprimes((double)n);
  Array primesArray= ((MWNumericArray)primes).
   ToVector(MWArrayComponent.Real);
  if (primesArray is double[])
   {
   double[] doubleArray= (double[])primesArray;
   /* Do something with doubleArray . . . */
   }
  else if (primesArray is float[])
   {
   float[] floatArray= (float[])primesArray;
   /* Do something with floatArray . . . */
   }
```

```
else if (primesArray is int[])
 {
 int[] intArray= (int[])primesArray;
 /*Do something with intArray . . . */
 }
else if (primesArray is long[])
 {
 long[] longArray= (long[])primesArray;
 /*Do something with longArray . . . */
 }
else if (primesArray is short[])
 {
 short[] shortArray= (short[])primesArray;
 /*Do something with shortArray . . . */
 }
else if (primesArray is byte[])
 {
 byte[] byteArray= (byte[])primesArray;
 /*Do something with byteArray . . . */
 }
else
 {
 throw new ApplicationException("
  Bad type returned from myprimes");
 }
}
```

The example uses the `toVector` method to return a .NET primitive array (`primesArray`), which represents the underlying MATLAB array. See the following code fragment from the example:

```
primes= myPrimesClass.myprimes((double)n);
  Array primesArray= ((MWNumericArray)primes).
   ToVector(MWArrayComponent.Real);
```

Note `toVector` is a method of the `MWNumericArray` class. It returns a copy of the array component in column major order. The type of the array elements is determined by the data type of the numeric array.

Using MWArray Query

The next example uses the MWNumericArray NumericType method, along with MWNumericType enumeration to determine the type of the underlying MATLAB array. See the switch (numericType) statement.

```
public void GetPrimes(int n)
{
 MWArray primes= null;
 MyPrimesClass myPrimesClass= null;
 try
  {
  myPrimesClass= new MyPrimesClass();
  primes= myPrimesClass.myprimes((double)n);
  if ((!primes.IsNumericArray) || (2 !=
   primes.NumberofDimensions))
   {
   throw new ApplicationException("Bad type returned
    by mwprimes");
   }
  MWNumericArray _primes= (MWNumericArray)primes;
  MWNumericType numericType= _primes.NumericType;
  Array primesArray= _primes.ToVector(
   MWArrayComponent.Real);
  switch (numericType)
   {
   case MWNumericType.Double:
    {
    double[] doubleArray= (double[])primesArray;
    /* (Do something with doubleArray . . .) */
    break;
    }
   case MWNumericType.Single:
    {
    float[] floatArray= (float[])primesArray;
    /* (Do something with floatArray . . .) */
    break;
    }
   case MWNumericType.Int32:
    {
    int[] intArray= (int[])primesArray;
```

```
      /* (Do something with intArray . . .) */
      break;
      }
     case MWNumericType.Int64:
      {
      long[] longArray= (long[])primesArray;
      /* (Do something with longArray . . .) */
      break;
      }
     case MWNumericType.Int16:
      {
      short[] shortArray= (short[])primesArray;
      /* (Do something with shortArray . . .) */
      break;
      }
     case MWNumericType.UInt8:
      {
      byte[] byteArray= (byte[])primesArray;
      /* (Do something with byteArray . . .) */
      break;
      }
     default:
      {
      throw new ApplicationException("Bad type returned
       by myprimes");
      }
     }
    }
```

The code in the example also checks the dimensionality by calling `NumberOfDimensions`; see the following code fragment:

```
if ((!primes.IsNumericArray) || (2 !=
  primes.NumberofDimensions))
  {
  throw new ApplicationException("Bad type returned
   by mwprimes");
```

This call throws an exception if the array is not numeric and of the proper dimension.

Handling Errors

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

Like any other .NET application, an application that calls a method generated by .NET Builder can handle errors by either

- Catching and handling the exception locally
- Allowing the calling method to catch it

Here are examples for each way of handling errors.

In the `GetPrimes` example the method itself handles the exception.

```
public double[] GetPrimes(int n)
{
 MWArray primes= null;
 MyPrimesClass myPrimesClass= null;
 try
  {
  myPrimesClass= new MyPrimesClass();
  primes= myPrimesClass.myprimes((double)n);
  return (double[])(MWNumericArray)primes).
        ToVector(MWArrayComponent.Real);
  }
 catch (Exception ex)
  {
  Console.WriteLine("Exception: {0}", ex);
  return new double[0];
  }
}
```

In the next example, the method that calls `myprimes` does not catch the exception. Instead, the its calling method (that is, the method that calls the method that calls `myprimes`) handles the exception.

```
public double[] GetPrimes(int n)
{
```

```
MWArray primes= null;
MyPrimesClass myPrimesClass= null;
try
 {
 myPrimesClass= new MyPrimesClass();
 primes= myPrimesClass.myprimes((double)n);
 return (double[])(MWNumericArray)primes).
       ToVector(MWArrayComponent.Real);
 }
}
```

Managing Native Resources

`MWArray` data conversion classes use native resources. That is, each class in the `MWArray` class hierarchy is a managed wrapper class that encapsulates a MATLAB `mxArray`, which is allocated from the native memory heap. Because the managed wrapper is small and the `mxArray` is comparatively large, the CLR memory manager does not call the garbage collector before the native memory becomes exhausted or badly fragmented.

Using Automated Garbage Collection

The recommended way to free native resources is to use the automated garbage collection provided by the `MWArray` classes.

The instantiation of an `MWArray` class creates a very *small* managed wrapper, which usually encapsulates a *moderate* to *large* `mxArray`, which is allocated from the native heap. During the execution of the application, as `MWArray` types continue to be instantiated, the native heap allocation continues to grow significantly while the managed memory allocation for the wrapper classes remains relatively small. As a result, the CLR garbage collector is called very infrequently, and the native heap becomes quickly depleted.

To address these issues, the `MWArray` data conversion classes keep track of the approximate size of the native memory allocations used by the encapsulated `mxArrays`. When a specified memory allocation threshold is reached, the CLR garbage collector is explicitly called to release any unused `MWArray` instances. When the CLR calls the finalizer for these instances, it frees the native memory allocated for the encapsulated `mxArray`. As a result, your code does not need to call a destructor explicitly.

Note The default memory management scheme for all .NET Builder components is to have the automatic memory management *enabled* with a *block size* of 10 MB. You can change the default.

Use an assembly attribute to explicitly enable or disable the `MWArray` memory management service and to specify the native memory allocation threshold.

The following C# segment explicitly enables memory management and sets the memory allocation threshold to 100M.

```
[assembly: NativeGC(true, GCBlockSize=100)]
```

Remember that if you do nothing, the default is to have the native memory management feature enabled.

The next two code segments are from "Magic Square Example" on page 1-10. They demonstrate how an application using .NET Builder components handles memory resource issues, with memory management disabled and enabled, respectively.

Managing Resources with Memory Management Disabled

```
MWArray Memory Management Disabled:

       [assembly: NativeGC(false)]

                              .
                              .
                              .

    int arraySize= System.Int32.Parse(args[0]);

    MagicSquare magic= new MagicSquare();

    // Return a magic square of the specified size
    // Note: the memory allocated by the explicit cast to an MWArray
    // scalar will not be released even by the finally clause.
    magicSquare= magic.makesquare((MWArray)arraySize);
  }

finally
  {
    // Explicitly free the native heap allocation for the magic square
    if (null != (Object)magicSquare) magicSquare.Dispose();
  }
```

Managing Resources with Memory Management Enabled

```
MWArray Memory Management Enabled:

      [assembly: NativeGC(true)] //Note that this is the default

                          .
                          .
                          .

   MagicSquare magic= new MagicSquare();

   // Return a magic square of the specified size
   magicSquare= magic.makesquare((MWArray)arraySize);

   // It is not necessary to call magicSquare.Dispose(). The native
   // memory allocated for it and the explicit cast will be
   // automatically recovered by the CLR garbage collector when the
   // memory allocation threshold is reached.
```

Alternative Ways to Free Native Resources

The automatic garbage collection provided by .NET Builder is the default as well as the recommended mechanism for memory management. If you do not choose to use the automatic garbage collection provided by .NET Builder, you might fail to discover memory usage generated by the .NET Builder because this memory usage is not always immediately visible to the user. Examples include implicit casts to the `MWArray` types.

Nonetheless, you can choose not to use the automatic garbage collection provided by .NET Builder; instead, you could use any of the following alternatives:

- "Using Garbage Collection Provided by the CLR" on page 3-19
- "Freeing Native Resources by Finalizing" on page 3-19
- "Using Dispose to Explicitly Free Resources" on page 3-19

Using Garbage Collection Provided by the CLR

When you create a new instance of a .NET class, the CLR allocates and initializes the new object. When this object goes out of scope, or becomes otherwise unreachable, it becomes eligible for garbage collection. The memory allocated by the object is eventually freed when the garbage collector is run.

`MWArray` objects also allocate space for native resources. Although these resources can be quite large, they are not visible to the CLR and will not be released by the class finalizer until the CLR determines that it is appropriate to run the garbage collector. To avoid exhausting the unmanaged memory heap, `MWArray` objects should be explicitly freed as soon as possible by the application that creates them (if automatic garbage collection has not been enabled).

Freeing Native Resources by Finalizing

The .NET Framework provides a semiautomatic mechanism called *finalization* to help clean up native resources just before garbage collection of the managed object. Objects that want to implement finalization do so by overriding the `Object.Finalize` method in their implementation. (How to override the `Object.Finalize` method depends on the language your are using; refer to your language reference for detailed information on how to override.)

The CLR invokes `Object.Finalize` just before garbage collection. There is no guarantee, however, on when garbage collection will take place.

An application has two ways to free native resources:

- Indeterminate — The CLR calls the `Finalize` destructor method for `MWArray` during garbage collection.
- Determinate — You call the `MWArray Dispose` method explicitly.

Using Dispose to Explicitly Free Resources

The following example allocates an 8 MB native array. To the CLR, the size of the wrapped object is just a few bytes (the size of an `MWNumericArray` instance) and thus not of significant size to trigger the garbage collector. For this reason, it is good practice to free the `MWArray` explicitly, unless you are using automatic garbage collection provided by the data conversion classes.

This ensures that the native array is also freed as part of running the finalizer method.

Usually the `Dispose` method is called from a `finally` section in a `try-finally` block as you can see in the following example:

```
try
 {
   /* Allocate a huge array */
   MWNumericArray array = new MWNumericArray(1000,1000);
  .
  .  (use the array)
  .
 }
finally
 {
   /* Explicitly dispose of the managed array and its */
   /* native resources */
 if (null != array)
  {
    array.Dispose();
  }
 }
```

The statement `array.Dispose()` frees the memory allocated by both the managed wrapper and the native MATLAB array.

The `MWArray` class provides two disposal methods: `Dispose` and `DisposeArray`. The `DisposeArray` method is more general in that it disposes of either a single `MWArray` or an array of arrays of type `MWArray`.

4

Sample Applications (C#)

Note The examples for MATLAB Builder for .NET are in `matlabroot\toolbox\dotnetbuilder\Examples\VS`*`versionnumber`*, where *`matlabroot`* is the directory where MATLAB is installed and`VS`*`versionnumber`* specifies the version of Microsoft Visual Studio .NET you are using (`VS7` or `VS8`). If you have Microsoft Visual Studio .NET installed, you can load projects for all the examples by opening the solution *`matlabroot`*`\toolbox\dotnetbuilder\Examples\VS`*`versionnumber`*`\DotNetExamples.sln`.

Plot Example (p. 4-2)	How to encapsulate a MATLAB function that draws a plot given two input arguments
Variable Arguments Example (p. 4-7)	How to pass a variable number of arguments
Spectral Analysis Example (p. 4-13)	How to create a .NET component containing more than one class
Matrix Math Example (p. 4-21)	How to assign more than one MATLAB function to a component class

---

Note In addition to these examples, see “Magic Square Example” on page 1-10 for a simple example that gets you started using MATLAB Builder for .NET.

Plot Example

The purpose of the example is to show you how to

- Use .NET Builder to convert a MATLAB function (`drawgraph`) to a method of a .NET class (`Plotter`) and wrap the class in a .NET component (`PlotDemoComp`).
- Access the component in a C# application (`PlotDemoApp.cs`) 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 MWArray Class Library Reference (available online only).

- Build and run the `PlotDemoApp` application, using the Visual Studio .NET development environment.

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

Step-by-Step Procedure

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

a. Copy the following directory that ships with MATLAB to your work directory:

```
matlabroot\toolbox\dotnetbuilder\Examples\VSversionnumber\PlotExample
```

b. At the MATLAB command prompt, `cd` to the new `PlotExample` subdirectory in your work directory.

2 Write the `drawgraph` function as you would any MATLAB function.

The following code defines the `drawgraph` function:

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

This code is already in your work directory in `PlotExample\PlotDemoComp\drawgraph.m`.

3 Specify a .NET component as follows:

a. While in MATLAB, issue the following command to open the Deployment Tool dialog box:

```
deploytool
```

b. Create a project with the following settings:

Setting	Value
Component name	`PlotDemoComp`
Class name	`Plotter`
Project directory	`\PlotExample\PlotDemoComp` subdirectory of your work directory
Show verbose output	Selected

c. Locate your work directory and navigate to the `MagicDemoComp` directory, which contains the M-file for the `makesquare` function. Add the `makesquare.m` file to the project.

4 Build the component by clicking the Build button in the Deployment Tool toolbar.

The build process begins, and a log of the build appears in the Output pane of the Deployment Tool. The files that are needed for the component are copied to two newly created subdirectories, `src` and `distrib`, in the `PlotDemoComp` directory. A copy of the build log is placed in the `src` directory.

See "What Happens in the Build Process?" on page 2-7 for more information.

5 Write source code for a C# application that accesses the component.

The sample application for this example is in *matlabroot*`\toolbox\dotnetbuilder\Examples\`*VSversionnumber*`\PlotExample\PlotDemoCSharpApp\PlotDemoApp.cs`.

The program listing is shown here.

PlotDemoApp.cs

```
// ******************************************************************************
//
// PlotDemoApp.cs
//
// This file is an example application for the MATLAB Builder for .NET product.
//
// Copyright 2001-2006 The MathWorks, Inc.
//
// ******************************************************************************



using System;

using MathWorks.MATLAB.NET.Utility;
using MathWorks.MATLAB.NET.Arrays;

using PlotDemoComp;

// Set native memory management block size to 25 MB.
[assembly: NativeGC(true, GCBlockSize= 25)]

namespace MathWorks.Demo.PlotDemoApp
{
  /// This application demonstrates plotting x-y data
  /// by graphing a simple parabola into a MATLAB figure
  /// dialog box.
  ///   class PlotDemoApp
    {
      #region MAIN

      /// The main entry point for the application.
      ///       [STAThread]
      static void Main(string[] args)
        {
          try
```

```
        {
          const int numPoints= 10;  // Number of points to plot

          // Allocate native array for plot values
          double [,] plotValues= new double[numPoints, 2];

          // Plot 5x vs x^2
          for (int x= 1; x <= numPoints; x++)
            {
              plotValues[x-1,0]= x*5;
              plotValues[x-1,1]= x*x;
            }

          // Create a new plotter object
          Plotter plotter= new Plotter();

          // Plot the two sets of values.
  // Note the automatic conversion of the native array
  // to a MATLAB array.
          plotter.drawgraph((MWNumericArray)plotValues);

          Console.ReadLine();  // Wait for user to exit application
        }

      catch(Exception exception)
        {
          Console.WriteLine("Error: {0}", exception);
        }
    }

  #endregion
  }
}
```

The program does the following:

- Creates two arrays of double values
- Creates a `Plotter` object .

- Calls the `drawgraph` method to plot the equation using the MATLAB `plot` function.
- Uses `MWNumericArray` to represent the data needed by the `drawgraph` method to plot the equation.
- Uses a `try-catch` block to catch and handle any exceptions.

The statement

```
Plotter plotter= new Plotter();
```

creates an instance of the `Plotter` class, and the statement

```
plotter.drawgraph((MWNumericArray)plotValues);
```

explicitly casts the native `plotValues` to `MWNumericArray` and then calls the method `drawgraph`.

6. Build the `PlotDemoApp` application using Visual Studio .NET.

   a. The `PlotDemoCSharpApp` directory contains a Visual Studio .NET project file for this example. Open the project in Visual Studio .NET by double-clicking `PlotDemoCSharpApp.csproj` in Windows Explorer. You can also open it from the MATLAB desktop by right-clicking **PlotDemoCSharpApp.csproj > Open Outside MATLAB**.

   b. If necessary, add a reference to the `MWArray` component, which is *`matlabroot`*`\bin\win32\MWArray.dll`.

   c. If necessary, add (or fix the location of) a reference to the `PlotDemoComp` component which you built in a previous step. (The component, `PlotDemo.dll`, is in the `\PlotExample\PlotDemoComp\distrib` subdirectory of your work area.)

7. Build and run the application in Visual Studio .NET.

Variable Arguments Example

Note This example is similar to "Plot Example" on page 4-2, except that the MATLAB function to be encapsulated takes a variable number of arguments instead of just one.

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

- How to use .NET Builder to convert a MATLAB function, `drawgraph`, which takes a variable number of arguments, to a method of a .NET class (`Plotter`) and wrap the class in a .NET component (`VarArgDemoComp`). The `drawgraph` function (which can be called as a method of the `Plotter` class) displays a plot of the input parameters.
- How to access the component in a C# application (`VarArgDemoApp.cs`) by instantiating the `Plotter` class and using `MWArray` to represent data.

  Note For complete reference information about the `MWArray` class hierarchy, see the MWArray Class Library Reference (available online only).

- How to build and run the `VarArgDemoApp` application, using the Visual Studio .NET development environment.

Step-by-Step Procedure

1. If you have not already done so, copy the files for this example as follows:
   a. Copy the following directory that ships with MATLAB to your work directory:

      ```
      matlabroot\toolbox\dotnetbuilder\Examples\VSversionnumber\VarArgExample
      ```

   b. At the MATLAB command prompt, `cd` to the new `VarArgExample` subdirectory in your work directory.

2. Write the MATLAB functions as you would any MATLAB function.

   The code for the functions in this example is as follows:

drawgraph.m

```
function [xyCoords] = DrawGraph(colorSpec, varargin)
...
    numVarArgIn= length(varargin);
    xyCoords= zeros(numVarArgIn, 2);

    for idx = 1:numVarArgIn
        xCoord = varargin{idx}(1);
        yCoord = varargin{idx}(2);

        x(idx) = xCoord;
        y(idx) = yCoord;

        xyCoords(idx,1) = xCoord;
        xyCoords(idx,2) = yCoord;
    end

    xmin = min(0, min(x));
    ymin = min(0, min(y));

    axis([xmin fix(max(x))+3 ymin fix(max(y))+3])

    plot(x, y, 'color', colorSpec);
```

extractcoords.m

```
function [varargout] = ExtractCoords(coords)
%EXTRACTCOORDS Extracts a variable number of two element x and y
% coordinate vectors from a two column array
%   [VARARGOUT] = EXTRACTCOORDS(COORDS) Extracts x,y coordinates
$   from a two column array
%   This file is used as an example for the .NET Builder
%   Language product.

%   Copyright 2001-2003 The MathWorks, Inc.
%   $Revision: 1.1.4.18 $  $Date: 2006/08/19 07:11:48 $
```

```
for idx = 1:nargout
    varargout{idx}= coords(idx,:);
end
```

This code is already in your work directory in `/VarArgExample/VarArgDemoComp/`.

3 Specify a .NET component as follows:

a. While in MATLAB, issue the following command to open the Deployment Tool dialog box:

```
deploytool
```

b. Create a project with the following settings:

Setting	Value
Component name	`VarArgDemoComp`
Class name	`Plotter`
Project directory	`\VarArgExample\VarArgDemoComp` subdirectory of your work directory
Show verbose output	Selected

c. Locate your work directory and navigate to the `VarArgDemoComp` directory, which contains the `drawgraph` and `extractcoords` functions. Add these two files to the project.

4 Build the component by clicking the Build button in the Deployment Tool toolbar.

The build process begins, and a log of the build appears in the Output pane of the Deployment Tool dialog box. The files that are needed for the component are copied to two newly created subdirectories, `src` and `distrib`, in the `VarArgDemoComp` directory. A copy of the build log is placed in the `src` directory.

See "What Happens in the Build Process?" on page 2-7 for more information.

5 Write source code for an application that accesses the component.

The sample application for this example is in `VarArgExample\VarArgDemoCSharpApp\VarArgDemoApp.cs`.

The program listing is shown here.

VarArgDemoApp.cs

```
// *******************************************************************************
//
// VarArgDemoApp.cs
//
// This file is an example application for the MATLAB Builder for .NET product.
//
// Copyright 2001-2006 The MathWorks, Inc.
//
// *******************************************************************************



using System;

using MathWorks.MATLAB.NET.Arrays;

using VarArgDemoComp;


namespace MathWorks.Demo.VarArgDemoApp
{
  /// <summary>
  /// This application demonstrates how to call components having methods with varargin/vargout arguments.
  /// </summary>
  class VarArgDemoApp
    {
      #region MAIN

      /// <summary>
      /// The main entry point for the application.
      /// </summary>
      [STAThread]
      static void Main(string[] args)
```

```
        {
          // Initialize the input data
          MWNumericArray colorSpec= new double[]{0.9, 0.0, 0.0};
          MWNumericArray data= new MWNumericArray(new int[,]{{1,2},{2,4},{3,6},{4,8},{5,10}});
          MWArray[] coords= null;

          try
            {
              // Create a new plotter object
              Plotter plotter= new Plotter();

              //Extract a variable number of two element x and y coordinate vectors from the data array
              coords= plotter.extractcoords(5, data);

              // Draw a graph using the specified color to connect the variable number of input coordinates.
              // Return a two column data array containing the input coordinates.
              data= (MWNumericArray)plotter.drawgraph((MWArray)colorSpec,
                                                coords[0], coords[1], coords[2],coords[3], coords[4]);

              Console.WriteLine("result=\n{0}", data);

              Console.ReadLine();  // Wait for user to exit application

              // Note: You can also pass in the coordinate array directly.
              data= (MWNumericArray)plotter.drawgraph((MWArray)colorSpec, coords);

              Console.WriteLine("result=\n{0}", data);

              Console.ReadLine();  // Wait for user to exit application
            }

          catch(Exception exception)
            {
              Console.WriteLine("Error: {0}", exception);
            }
        }

      #endregion
    }
}
```

The program does the following:

- Initializes three arrays (`colorSpec`, `data`, and `coords`) using the `MWArray` class library
- Creates a `Plotter` object
- Calls the `extracoords` and `drawgraph` methods
- Uses `MWNumericArray` to represent the data needed by the methods
- Uses a `try-catch` block to catch and handle any exceptions

The following statements are alternative ways to call the `drawgraph` method:

```
data= (MWNumericArray)plotter.drawgraph((MWArray)colorSpec,
               coords[0], coords[1], coords[2],coords[3], coords[4]);
...
data= (MWNumericArray)plotter.drawgraph((MWArray)colorSpec, coords);
```

6 Build the `VarArgDemoApp` application using Visual Studio .NET.

   a. The `VarArgDemoCSharpApp` directory contains a Visual Studio .NET project file for this example. Open the project in Visual Studio .NET by double-clicking `VarArgDemoCSharpApp.csproj` in Windows Explorer. You can also open it from the MATLAB desktop by right-clicking **VarArgDemoCSharpApp.csproj > Open Outside MATLAB**.

   b. If necessary, add a reference to the `MWArray` component, which is *`matlabroot`*`\bin\win32\MWArray.dll`.

   c. If necessary, add (or fix the location of) a reference to the `VarArgDemoComp` component which you built in a previous step. (The component, `VarArgDemo.dll`, is in the `\VarArgExample\VarArgDemoComp\distrib` subdirectory of your work area.)

7 Build and run the application in Visual Studio .NET.

Spectral Analysis Example

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

- How to use MATLAB Builder for .NET to create a component (`SpectraDemoComp`) containing more than one class.
- How to access the component in a C# application (`SpectraDemoApp.cs`), including use of the `MWArray` class hierarchy to represent data.

Note For complete reference information about the `MWArray` class hierarchy, see the MWArray Class Library Reference (available online only).

- How to build and run the application, using the Visual Studio .NET development environment.

The component `SpectraDemo` analyzes a signal and graphs the result. The class, `SignalAnalyzer`, 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 class, `Plotter`, graphs the returned data using the `plotfft` method. These two methods, `computefft` and `plotfft`, encapsulate MATLAB functions.

The `computefft` method computes the FFT and power spectral density of the input data and computes a vector of frequency points based on the length of the data entered and the sampling interval. The `plotfft` method plots the FFT data and the power spectral density in a MATLAB figure window. The MATLAB code for these two methods resides in two M-files, `computefft.m` and `plotfft.m`, which can be found in:

```
matlabroot\toolbox\dotnetbuilder\Examples\VSversionnumber\SpectraExample\SpectraDemoComp
```

computefft.m

```
function [fftData, freq, powerSpect] = ComputeFFT(data, interval)
%COMPUTEFFT Computes the FFT and power spectral density.
%   [FFTDATA, FREQ, POWERSPECT] = COMPUTEFFT(DATA, INTERVAL)
%   Computes the FFT and power spectral density of the input data.
%   This file is used as an example for the .NET Builder
```

```
%   Language product.
%   Copyright 2001-2003 The MathWorks, Inc.
if (isempty(data))
   fftdata = [];
   freq = [];
   powerspect = [];
   return;
end
if (interval <= 0)
   error('Sampling interval must be greater then zero');
   return;
end
fftData = fft(data);
freq = (0:length(fftData)-1)/(length(fftData)*interval);
powerSpect = abs(fftData)/(sqrt(length(fftData)));
```

plotfft.m

```
function PlotFFT(fftData, freq, powerSpect)
%PLOTFFT Computes and plots the FFT and power spectral density.
%   [FFTDATA, FREQ, POWERSPECT] = PLOTFFT(DATA, INTERVAL)
%   Computes the FFT and power spectral density of the input data.
%   This file is used as an example for the .NET Builder
%   Language product.
%   Copyright 2001-2003 The MathWorks, Inc.
len = length(fftData);
    if (len <= 0)
        return;
    end
    plot(freq(1:floor(len/2)), powerSpect(1:floor(len/2)))
    xlabel('Frequency (Hz)'), grid on
    title('Power spectral density')
```

Step-by-Step Procedure

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

a. Copy the following directory that ships with MATLAB to your work directory:

```
matlabroot\toolbox\dotnetbuilder\Examples\VSversionnumber\SpectraExample
```

b. At the MATLAB command prompt, `cd` to the new `SpectraExample` subdirectory in your work directory.

2 Write the M-code that you want to access.

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

3 Specify a .NET component as follows:

a. While in MATLAB, issue the following command to open the Deployment Tool dialog box:

```
deploytool
```

b. Create a project with the following settings:

Setting	Value
Component name	`SpectraDemoComp`
Class name	`Plotter` `SignalAnalyzer`
Project directory	`\SpectraExample\SpectraDemoComp` subdirectory of your work directory
Show verbose output	Selected

c. Locate your work directory and navigate to the `SpectraDemoComp` directory.

d. Add the `plotfft.m` file to the `Plotter` class.

e. Similarly, add the `computefft.m` file to the `SignalAnalyzer` class.

4 Build the component by clicking the Build button in the Deployment Tool toolbar.

The build process begins, and a log of the build appears in the Output pane of the Deployment Tool dialog box. The files that are needed for the component are copied to two newly created subdirectories, `src` and

distrib, in the SpectraDemoComp directory. A copy of the build log is placed in the src directory.

See "What Happens in the Build Process?" on page 2-7 for more information.

5 Write source code for an application that accesses the component.

The sample application for this example is in SpectraExample\SpectraDemoCSharpApp\SpectraDemoApp.cs.

The program listing is shown here.

SpectraDemoApp.cs

```
// *******************************************************************************
//
// SpectraDemoApp.cs
//
// This file is an example application for the MATLAB Builder for .NET product.
//
// Copyright 2001-2006 The MathWorks, Inc.
//
// *******************************************************************************



using System;

using MathWorks.MATLAB.NET.Utility;
using MathWorks.MATLAB.NET.Arrays;

using SpectraDemoComp;


namespace MathWorks.Demo.SpectraDemoApp
{
  /// <summary>
  /// This application computes and plots the power spectral density of an input signal.
  /// </summary>
  class SpectraDemoApp
```

```
{
  #region MAIN

  /// <summary>
  /// The main entry point for the application.
  /// </summary>
  [STAThread]
  static void Main(string[] args)
    {
      try
        {
          const double interval= 0.01;  // The sampling interval
          const int numSamples= 1001;   // The number of samples

          // Construct input data as sin(2*PI*15*t) + (sin(2*PI*40*t) plus a
          // random signal.  Duration= 10; Sampling interval= 0.01
          MWNumericArray data= new MWNumericArray(MWArrayComplexity.Real, MWNumericType.Double, numSamples);

          Random random= new Random();

          // Initialize data
          for (int idx= 1; idx <= numSamples; idx++)
            {
              double t= (idx-1)* interval;

              data[idx]= Math.Sin(2.0*Math.PI*15.0*t) + Math.Sin(2.0*Math.PI*40.0*t) + random.NextDouble();
            }

          // Create a new signal analyzer object
          SignalAnalyzer signalAnalyzer= new SignalAnalyzer();

          // Compute the fft and power spectral density for the data array
          MWArray[] argsOut= signalAnalyzer.computefft(3, data, interval);

          // Print the first twenty elements of each result array
          int numElements= 20;
        MWNumericArray resultArray= new MWNumericArray(MWArrayComplexity.Complex, MWNumericType.Double, numElements);

        for (int idx= 1; idx <= numElements; idx++)
          {
```

```
            resultArray[idx]= ((MWNumericArray)argsOut[0])[idx];
          }

        Console.WriteLine("FFT:\n{0}\n", resultArray);

          for (int idx= 1; idx <= numElements; idx++)
            {
              resultArray[idx]= ((MWNumericArray)argsOut[1])[idx];
            }

          Console.WriteLine("Frequency:\n{0}\n", resultArray);

          for (int idx= 1; idx <= numElements; idx++)
            {
              resultArray[idx]= ((MWNumericArray)argsOut[2])[idx];
            }

          Console.WriteLine("Power Spectral Density:\n{0}", resultArray);

          // Create a new plotter object
          Plotter plotter= new Plotter();

          // Plot the fft and power spectral density for the data array
          plotter.plotfft(argsOut[0], argsOut[1], argsOut[2]);

          Console.ReadLine();  // Wait for user to exit application
        }

      catch(Exception exception)
        {
          Console.WriteLine("Error: {0}", exception);
        }
    }

  #endregion
  }
}
```

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
- Instantiates a `SignalAnalyzer` object
- Calls the `computefft` method, which computes the FFT, frequency, and the spectral density
- Instantiates a `Plotter` object
- Calls the `plotfft` method, which plots the data
- Uses a `try/catch` block to handle exceptions

The following statement

```
MWNumericArray data= new MWNumericArray(MWArrayComplexity.Real,
MWNumericType.Double, numSamples);
```

shows how to use the MWArray class library to construct a `MWNumeric` array that is used as method input to the `computefft` function.

The following statement

```
SignalAnalyzer signalAnalyzer = new SignalAnalyzer();
```

creates an instance of the class `SignalAnalyzer`, and the following statement

```
MWArray[] argsOut= signalAnalyzer.computefft(3, data, interval);
```

calls the method `computefft`.

6 Build the `SpectraDemoApp` application using Visual Studio .NET.

a. The `SpectraDemoCSharpApp` directory contains a Visual Studio .NET project file for this example. Open the project in Visual Studio .NET by double-clicking `SpectraDemoCSharpApp.csproj` in Windows Explorer. You can also open it from the MATLAB desktop by right-clicking **SpectraDemoCSharpApp.csproj > Open Outside MATLAB**.

b. If necessary, add a reference to the `MWArray` component, which is *`matlabroot`*`\bin\win32\MWArray.dll`.

c. If necessary, add (or fix the location of) a reference to the `SpectraDemo` component which you built in a previous step. (The component, `SpectraDemo.dll`, is in the `\SpectraExample\SpectraDemoComp\distrib` subdirectory of your work area.)

7 Build and run the application in Visual Studio .NET.

Matrix Math Example

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

- How to assign more than one MATLAB function to a component class.
- How to manually handle native memory management by disabling the default memory manager for MWArray.
- How to access the component in a C# application (`MatrixMathDemoApp.cs`) 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 MWArray Class Library Reference (available online only).

- How to build and run the `MatrixMathDemoApp` application, using the Visual Studio .NET development environment.

This example builds a .NET component 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 = [ 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 ]
```

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)
%CHOLESKY Cholesky factorization of A.
%   L= CHOLESKY(A) returns the Cholesky factorization of A.
%   This file is used as an example for the .NET Builder
%   Language product.

%   Copyright 2001-2003 The MathWorks, Inc.
%   $Revision: 1.1.4.18 $  $Date: 2006/08/19 07:11:48 $

    L = chol(A);
```

ludecomp.m

```
function [L,U] = LUDecomp(A)
%LUDECOMP LU factorization of A.
%   [L,U]= LUDECOMP(A) returns the LU factorization of A.
%   This file is used as an example for the .NET Builder
%   Language product.

%   Copyright 2001-2003 The MathWorks, Inc.
%   $Revision: 1.1.4.18 $  $Date: 2006/08/19 07:11:48 $

    [L,U] = lu(A);
```

qrdecomp.m

```
function [Q,R] = QRDecomp(A)
%QRDECOMP QR factorization of A.
%   [Q,R]= QRDECOMP(A) returns the QR factorization of A.
%   This file is used as an example for the .NET Builder
%   Language product.

%   Copyright 2001-2003 The MathWorks, Inc.
%   $Revision: 1.1.4.18 $  $Date: 2006/08/19 07:11:48 $

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

Step-by-Step Procedure

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

a. Copy the following directory that ships with MATLAB to your work directory:

```
matlabroot\toolbox\dotnetbuilder\Examples\VSversionnumber\MatrixMathExample
```

b. At the MATLAB command prompt, `cd` to the new `MatrixMathExample` subdirectory in your work directory.

2 Write the MATLAB functions as you would any MATLAB function.

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

3 Specify a .NET component as follows:

a. While in MATLAB, issue the following command to open Deployment Tool:

```
deploytool
```

b. Create a project with the following settings:

Setting	Value
Component name	`MatrixMathDemoComp`
Class name	`Factor`
Project directory	`\MatrixMathExample\MatrixMathDemoComp` subdirectory of your work directory
Show verbose output	Selected

c. Locate your work directory and navigate to the `MatrixMathDemoComp` directory, which contains the M-files for the `cholesky, ludecomp, and qrdecomp` functions.

d. Add the three M-files to the `Factor` class.

4 Build the component by clicking the Build button in the Deployment Tool toolbar.

   The build process begins, and a log of the build appears in the Output pane of the Deployment Tool dialog box. The files that are needed for the component are copied to two newly created subdirectories, `src` and `distrib`, in the `MatrixMathDemoComp` directory. A copy of the build log is placed in the `src` directory.

   See "What Happens in the Build Process?" on page 2-7 for more information.

5 Write source code for an application that accesses the component.

   The sample application for this example is in `MatrixMathExample\MatrixMathDemoCSharpApp\MatrixMathDemoApp.cs`.

   The program listing is shown here.

   MatrixMathDemoApp.cs

```
// *******************************************************************************
//
// MatrixMathDemoApp.cs
//
// This file is an example application for the MATLAB Builder for .NET product.
//
// Copyright 2001-2006 The MathWorks, Inc.
//
// *******************************************************************************



using System;

using MathWorks.MATLAB.NET.Utility;
using MathWorks.MATLAB.NET.Arrays;

using MatrixMathDemoComp;
```

```
[assembly: NativeGC(false)]  // Disable Automatic native memory management

namespace MathWorks.Demo.MatrixMathApp
{
  /// <summary>
  /// This application computes cholesky, LU, and QR factorizations of a finite difference matrix of order N.
  /// The order is passed into the application on the command line.
  /// </summary>
  /// <remarks>
  /// Command Line Arguments:
  /// <newpara></newpara>
  /// args[0] - Matrix order(N)
  /// <newpara></newpara>
  /// args[1] - (optional) sparse; Use a sparse matrix
  /// </remarks>
  class MatrixMathDemoApp
    {
      #region MAIN

      /// <summary>
      /// The main entry point for the application.
      /// </summary>
      [STAThread]
      static void Main(string[] args)
        {
          bool makeSparse= true;
          int matrixOrder= 4;

          MWNumericArray matrix= null; // The matrix to factor

          MWArray argOut= null;     // Stores single factorization result
          MWArray[] argsOut= null;  // Stores multiple factorization results

          try
            {
              // If no argument specified, use defaults
              if (0 != args.Length)
                {
                  // Convert matrix order
                  matrixOrder= System.Int32.Parse(args[0]);
```

```
    if (0 >= matrixOrder)
      {
        throw new ArgumentOutOfRangeException("matrixOrder", matrixOrder,
                                              "Must enter a positive integer for the matrix order(N)");
      }

    makeSparse= ((1 < args.Length) && (args[1].Equals("sparse")));
  }

// Create the test matrix.  If the second argument is "sparse", create a sparse matrix.
matrix= (makeSparse)
    ? MWNumericArray.MakeSparse(matrixOrder, matrixOrder, MWArrayComplexity.Real,
             (matrixOrder+(2*(matrixOrder-1))))
    : new MWNumericArray(MWArrayComplexity.Real, MWNumericType.Double, matrixOrder, matrixOrder);

// Initialize the test matrix
for (int rowIdx= 1; rowIdx <= matrixOrder; rowIdx++)
  for (int colIdx= 1; colIdx <= matrixOrder; colIdx++)
    if (rowIdx == colIdx)
      matrix[rowIdx, colIdx]= 2.0;
    else if ((colIdx == rowIdx+1) || (colIdx == rowIdx-1))
      matrix[rowIdx, colIdx]= -1.0;

// Create a new factor object
Factor factor= new Factor();

// Print the test matrix
Console.WriteLine("Test Matrix:\n{0}\n", matrix);

// Compute and print the cholesky factorization using the single output syntax
argOut= factor.cholesky((MWArray)matrix);

Console.WriteLine("Cholesky Factorization:\n{0}\n", argOut);

// Compute and print the LU factorization using the multiple output syntax
argsOut= factor.ludecomp(2, matrix);

Console.WriteLine("LU Factorization:\nL Matrix:\n{0}\nU Matrix:\n{1}\n", argsOut[0], argsOut[1]);
```

```
            MWNumericArray.DisposeArray(argsOut);

            // Compute and print the QR factorization
            argsOut= factor.qrdecomp(2, matrix);

            Console.WriteLine("QR Factorization:\nQ Matrix:\n{0}\nR Matrix:\n{1}\n", argsOut[0], argsOut[1]);

            Console.ReadLine();
          }

        catch(Exception exception)
          {
            Console.WriteLine("Error: {0}", exception);
          }

        finally
          {
            // Free native resources
            if (null != (object)matrix) matrix.Dispose();
            if (null != (object)argOut) argOut.Dispose();

            MWNumericArray.DisposeArray(argsOut);
          }
      }

    #endregion
  }
}
```

The statement

```
Factor factor= new Factor();
```

creates an instance of the class `Factor`.

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

```
argOut= factor.cholesky((MWArray)matrix);
...
```

```
argsOut= factor.ludecomp(2, matrix);
...
argsOut= factor.qrdecomp(2, matrix);
...
```

Note See "Understanding the MatrixMathDemo Program" on page 4-28 for more details about the structure of this program.

---

6 Build the `MatrixMathDemoApp` application using Visual Studio .NET.

   a. The `MatrixMathDemoCSharpApp` directory contains a Visual Studio .NET project file for this example. Open the project in Visual Studio .NET by double-clicking `MatrixMathDemoCSharpApp.csproj` in Windows Explorer. You can also open it from the MATLAB desktop by right-clicking **MatrixMathDemoCSharpApp.csproj > Open Outside MATLAB**.

   b. If necessary, add a reference to the `MWArray` component, which is `matlabroot\bin\win32\MWArray.dll`.

   c. If necessary, add (or fix the location of) a reference to the `MatrixMathDemoComp` component which you built in a previous step. (The component, `MatrixMathDemo.dll`, is in the `\MatrixMathExample\MatrixMathDemoComp\distrib` subdirectory of your work area.)

7 Build and run the application in Visual Studio .NET.

Understanding the MatrixMathDemo Program

The `MatrixMathDemo` program takes one or two arguments from the command line. 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.

The main method has three parts:

- The first part sets up the input matrix, creates a new factor object, and calls the `cholesky`, `ludecomp`, 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.

5

Sample Applications (Visual Basic)

The sample applications that follow use the same components as those developed in "Magic Square Example" on page 1-10 and Chapter 4, "Sample Applications (C#)". Instead of C#, the following applications are written in Visual Basic .NET. For details about creating the components, see the procedures noted in the beginning of the description for each application. Then follow the steps shown here to use the component in a Visual Basic application.

Magic Square Example (Visual Basic) (p. 5-3)	Step-by-step example showing code for a simple Visual Basic .NET application
Create Plot Example (Visual Basic) (p. 5-7)	Step-by-step example showing code that uses two input arguments
Variable Arguments Example (Visual Basic) (p. 5-11)	Step-by-step example showing code for a simple Visual Basic .NET application that passes a variable number of arguments
Spectral Analysis Example (Visual Basic) (p. 5-15)	Step-by-step example showing code for a simple Visual Basic .NET application that performs an FFT on an input data array
MatrixMath Example (Visual Basic) (p. 5-20)	Step-by-step example showing code for a simple Visual Basic .NET application that performs Cholesky, LU, and QR factorizations on a simple tridiagonal matrix

---

Note The examples for MATLAB Builder for .NET are in `matlabroot\toolbox\dotnetbuilder\Examples\VS`*`versionnumber`*, where *`matlabroot`* is the directory where MATLAB is installed and`VS`*`versionnumber`* specifies the version of Microsoft Visual Studio .NET you are using (`VS7` or `VS8`). If you have Microsoft Visual Studio .NET installed, you can load projects for all the examples by opening the following solution:

```
matlabroot\toolbox\dotnetbuilder\Examples\VSversionnumber\DotNetExamples.sln
```

Magic Square Example (Visual Basic)

To create the component for this example, see the first several steps in "Magic Square Example" on page 1-10. After you build the `MagicDemoComp` component, you can build an application that accesses the component as follows.

1 For this example, the application is `MagicDemoApp.vb`.

   You can find `MagicDemoApp.vb` in:

```
matlabroot\toolbox\dotnetbuilder\Examples\VSversionnumber
  \MagicSquareExample\MagicDemoVBApp\MagicSquareExample\MagicDemoVBApp
```

   The program listing is as follows.

MagicDemoApp.vb

```
' ********************************************************************************
'
' MagicDemoApp.vb
'
' This file is an example application for the MATLAB Builder for .NET product.
'
' Copyright 2001-2006 The MathWorks, Inc.
'
' ********************************************************************************

Imports System
Imports System.Reflection
Imports MathWorks.MATLAB.NET.Utility
Imports MathWorks.MATLAB.NET.Arrays

Imports MagicDemoComp

Namespace MathWorks.Demo.MagicSquareApp

    ' <summary>
    ' The MagicDemoApp class computes a magic square of the user specified size.
    ' </summary>
```

```
    ' <remarks>
    ' args[0] - a positive integer representing the array size.
    ' </remarks>
    Class MagicDemoApp

#Region " MAIN "

        ' <summary>
        ' The main entry point for the application.
        ' </summary>
        Shared Sub Main(ByVal args() As String)

            Dim arraySize As MWNumericArray = Nothing
            Dim magicSquare As MWNumericArray = Nothing

            Try
                ' Get user specified command line arguments or set default
                If (0 <> args.Length) Then
                    arraySize = New MWNumericArray(System.Int32.Parse(args(0)), False)
                Else
                    arraySize = New MWNumericArray(4, False)
                End If

                ' Create the magic square object
                Dim magic As MagicSquare = New MagicSquare

                ' Compute the magic square and print the result
                magicSquare = magic.makesquare(arraySize)

                Console.WriteLine("Magic square of order {0}{1}{2}{3}", arraySize, Chr(10), Chr(10), magicSquare)

                ' Convert the magic square array to a two dimensional native double array
                Dim nativeArray(,) As Double = CType(magicSquare.ToArray(MWArrayComponent.Real), Double(,))

                Console.WriteLine("{0}Magic square as native array:{1}", Chr(10), Chr(10))

                ' Display the array elements:
                Dim index As Integer = arraySize.ToScalarInteger()

                For i As Integer = 0 To index - 1
```

```
                For j As Integer = 0 To index - 1
                    Console.WriteLine("Element({0},{1})= {2}", i, j, nativeArray(i, j))
                Next j
            Next i

            Console.ReadLine() 'Wait for user to exit application


        Catch exception As Exception

            Console.WriteLine("Error: {0}", exception)

        End Try
    End Sub
#End Region

    End Class

End Namespace
```

The application you build from this source file does the following:

- Lets you pass a dimension for the magic square from the command line.
- Converts the dimension argument to a MATLAB integer scalar value.
- Declares variables of type `MWNumericArray` to handle data required by the encapsulated `makesquare` function.

Note For complete reference information about the `MWArray` class hierarchy, see the MWArray Class Library Reference (available online only).

- Creates an instance of the `MagicSquare` class named `magic`.
- Calls the `makesquare` method, which belongs to the `magic` object. The `makesquare` method generates the magic square using the MATLAB `magic` function.
- Displays the array elements on the command line.

2 Build the application using Visual Studio .NET.

a. The `MagicDemoVBApp` directory contains a Visual Studio .NET project file for each example. Open the project in Visual Studio .NET for this example by double-clicking `MagicDemoVBApp.vbproj` in Windows Explorer.

b. If necessary, add a reference to the `MWArray` component, which is *`matlabroot`*`\bin\win32\MWArray.dll.`

c. If necessary, add a reference to the `MagicDemoComp` component, which is in the `distrib` subdirectory.

d. Build and run the application in Visual Studio .NET.

The first time you run the application, Visual Studio .NET creates a directory named `MagicDemo_MCR` in `MagicSsquareExample\bin\debug`. The `MagicDemo_MCR` directory contains encrypted versions of M-files that the `MagicSquare` component class encapsulates.

Create Plot Example (Visual Basic)

To create the component for this example, see “Plot Example” on page 4-2. Then create a Visual Basic application as follows.

1. The sample application for this example is in *matlabroot*\toolbox\dotnetbuilder\Examples*VSversionnumber*\PlotExample\PlotDemoVBApp\PlotDemoApp.vb.

   The program listing is shown here.

   PlotDemoApp.vb

```
' *******************************************************************************
'
' PlotDemoApp.vb
'
' This file is an example application for the MATLAB Builder for .NET product.
'
' Copyright 2001-2006 The MathWorks, Inc.
'
' *******************************************************************************

Imports System

Imports MathWorks.MATLAB.NET.Utility
Imports MathWorks.MATLAB.NET.Arrays

Imports PlotDemoComp


<Assembly: NativeGC(True, GCBlockSize:=25)>    ' Set native memory management block size to 25 MB.
Namespace MathWorks.Demo.PlotDemoApp

' <summary>
' This application demonstrates plotting x-y data by graphing a simple
' parabola into a MATLAB figure window.
' </summary>
    Class PlotDemoApp
```

```
#Region " MAIN "

        ' <summary>
        ' The main entry point for the application.
        ' </summary>
        Shared Sub Main(ByVal args() As String)
            Try
                Const numPoints As Integer = 10  ' Number of points to plot
                Dim idx As Integer
                Dim plotValues(,) As Double = New Double(1, numPoints - 1) {}
                Dim coords As MWNumericArray

                'Plot 5x vs x^2
                For idx = 0 To numPoints - 1
                    Dim x As Double = idx + 1
                    plotValues(0, idx) = x * 5
                    plotValues(1, idx) = x * x
                Next idx

                coords = New MWNumericArray(plotValues)

                ' Create a new plotter object
                Dim plotter As Plotter = New Plotter

                ' Plot the values
                plotter.drawgraph(coords)

                Console.ReadLine()  ' Wait for user to exit application

            Catch exception As Exception
                Console.WriteLine("Error: {0}", exception)
            End Try
        End Sub
#End Region

    End Class
End Namespace
```

The program does the following:

- Creates two arrays of double values
- Creates a `Plotter` object
- Calls the `drawgraph` method to plot the equation using the MATLAB `plot` function
- Uses `MWNumericArray` to handle the data needed by the `drawgraph` method to plot the equation

---

Note For complete reference information about the `MWArray` class hierarchy, see the MWArray Class Library Reference (available online only).

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

The statement

```
Dim plotter As Plotter = New Plotter
```

creates an instance of the `Plotter` class, and the statement

```
plotter.drawgraph(coords)
```

calls the method `drawgraph`.

2 Build the `PlotDemoApp` application using Visual Studio .NET.

a. The `PlotDemoVBApp` directory contains a Visual Studio .NET project file for this example. Open the project in Visual Studio .NET by double-clicking `PlotDemoVBApp.vbproj` in Windows Explorer. You can also open it from the MATLAB desktop by right-clicking **PlotDemoVBApp.vbproj > Open Outside MATLAB**.

b. If necessary, add a reference to the `MWArray` component, which is *`matlabroot`*`\bin\win32\MWArray.dll`.

c. If necessary, add (or fix the location of) a reference to the `PlotDemoComp` component which you built in a previous step. (The component, `PlotDemo.dll`, is in the `\PlotExample\PlotDemoComp\distrib` subdirectory of your work area.)

3. Build and run the application in Visual Studio .NET.

Variable Arguments Example (Visual Basic)

To create the component for this example, see "Variable Arguments Example" on page 4-7. Then create a Visual Basic application as follows.

1 The sample application for this example is in `matlabroot\toolbox\dotnetbuilder\Examples\VSversionnumber\VarArgExample\VarArgDemoVBApp\VarArgDemoApp.vb`.

The program listing is shown here.

VarArgDemoApp.vb

```
' *******************************************************************************
'
' VarArgDemoApp.vb
'
' This file is an example application for the MATLAB Builder for .NET product.
'
' Copyright 2001-2006 The MathWorks, Inc.
'
' *******************************************************************************

Imports System

Imports MathWorks.MATLAB.NET.Utility
Imports MathWorks.MATLAB.NET.Arrays

Imports VarArgDemoComp


Namespace MathWorks.Demo.VarArgDemoApp


' <summary>
' This application demonstrates how to call components having methods with varargin/vargout arguments.
' </summary>
Class VarArgDemoApp

#Region " MAIN "
```

```
' <summary>
' The main entry point for the application.
' </summary>
Shared Sub Main(ByVal args() As String)

    ' Initialize the input data
    Dim colorSpec As MWNumericArray = New MWNumericArray(New Double() {0.9, 0.0, 0.0})
    Dim data As MWNumericArray = New MWNumericArray(New Integer(,) {{1, 2}, {2, 4}, {3, 6}, {4, 8}, {5, 10}})
    Dim coords() As MWArray = Nothing

    Try

        ' Create a new plotter object
        Dim plotter As Plotter = New Plotter

        'Extract a variable number of two element x and y coordinate vectors from the data array
        coords = plotter.extractcoords(5, data)

        ' Draw a graph using the specified color to connect the variable number of input coordinates.
        ' Return a two column data array containing the input coordinates.
        data = CType(plotter.drawgraph(colorSpec, coords(0), coords(1), coords(2), coords(3), coords(4)),_
                      MWNumericArray)

        Console.WriteLine("result={0}{1}", Chr(10), data)

        Console.ReadLine()  ' Wait for user to exit application

        ' Note: You can also pass in the coordinate array directly.
        data = CType(plotter.drawgraph(colorSpec, coords), MWNumericArray)

        Console.WriteLine("result=\{0}{1}", Chr(10), data)

        Console.ReadLine()  ' Wait for user to exit application


    Catch exception As Exception
        Console.WriteLine("Error: {0}", exception)
    End Try
End Sub
```

```
#End Region

    End Class
End Namespace
```

The program does the following:

- Initializes three arrays (`colorSpec`, `data`, and `coords`) using the `MWArray` class library
- Creates a `Plotter` object
- Calls the `extracoords` and `drawgraph` methods
- Uses `MWNumericArray` to handle the data needed by the methods

Note For complete reference information about the `MWArray` class hierarchy, see the MWArray Class Library Reference (available online only).

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

The following statements are alternative ways to call the `drawgraph` method:

```
data = CType(plotter.drawgraph(colorSpec, coords(0), coords(1), coords(2), coords(3), coords(4)), MWNumericArray)
...
data = CType(plotter.drawgraph(colorSpec, coords), MWNumericArray)
```

2 Build the `VarArgDemoApp` application using Visual Studio .NET.

a. The `VarArgDemoVBApp` directory contains a Visual Studio .NET project file for this example. Open the project in Visual Studio .NET by double-clicking `VarArgDemoVBApp.vbproj` in Windows Explorer. You can also open it from the MATLAB desktop by right-clicking **VarArgDemoVBApp.vbproj > Open Outside MATLAB**.

b. If necessary, add a reference to the `MWArray` component, which is *`matlabroot`*`\bin\win32\MWArray.dll.`

c. If necessary, add (or update the location of) a reference to the `VarArgDemoComp` component which you built in a previous step. (The component, `VarArgDemo.dll`, is in the `\VarArgExample\VarArgDemoComp\distrib` subdirectory of your work area.)

3 Build and run the application in Visual Studio .NET.

Spectral Analysis Example (Visual Basic)

To create the component for this example, see the first few steps of the "Spectral Analysis Example" on page 4-13. Then create a Visual Basic application as follows.

1 The sample application for this example is in *matlabroot*\toolbox\dotnetbuilder\Examples*VSversionnumber*\SpectraExample \SpectraDemoVBApp\SpectraDemoApp.vb.

The program listing is shown here.

SpectraDemoApp.vb

```
' *******************************************************************************
'
' SpectraDemoApp.vb
'
' This file is an example application for the MATLAB Builder for .NET product.
'
' Copyright 2001-2006 The MathWorks, Inc.
'
' *******************************************************************************

Imports System

Imports MathWorks.MATLAB.NET.Utility
Imports MathWorks.MATLAB.NET.Arrays

Imports SpectraDemoComp



Namespace MathWorks.Demo.SpectraDemoApp

' <summary>
' This application computes and plots the power spectral density of an input signal.
' </summary>
Class SpectraDemoApp

#Region " MAIN "
```

```
' <summary>
 ' The main entry point for the application.
 ' </summary>
 Shared Sub Main(ByVal args() As String)
     Try
         Const interval As Double = 0.01   ' The sampling interval
         Const numSamples As Integer = 1001   ' The number of samples

         ' Construct input data as sin(2*PI*15*t) + (sin(2*PI*40*t) plus a
         ' random signal.  Duration= 10; Sampling interval= 0.01
         Dim data As MWNumericArray = New MWNumericArray(MWArrayComplexity.Real, MWNumericType.Double, numSamples)

         Dim random As Random = New Random

         ' Initialize data
         Dim t As Double
         Dim idx As Integer
         For idx = 1 To numSamples
             t = (idx - 1) * interval
             data(idx) = New MWNumericArray(Math.Sin(2.0 * Math.PI * 15.0 * t) + _
                         Math.Sin(2.0 * Math.PI * 40.0 * t) + random.NextDouble())
         Next idx

         ' Create a new signal analyzer object
         Dim signalAnalyzer As SignalAnalyzer = New SignalAnalyzer

         ' Compute the fft and power spectral density for the data array
         Dim argsOut() As MWArray = signalAnalyzer.computefft(3, data, MWArray.op_Implicit(interval))

         ' Print the first twenty elements of each result array
         Dim numElements As Integer = 20
         Dim resultArray As MWNumericArray = New MWNumericArray(MWArrayComplexity.Complex, MWNumericType.Double, numElements)

         For idx = 1 To numElements
             resultArray(idx) = (CType(argsOut(0), MWNumericArray))(idx)
         Next idx

         Console.WriteLine("FFT:{0}{1}{2}", Chr(10), resultArray, Chr(10))
```

```
            For idx = 1 To numElements
                resultArray(idx) = (CType(argsOut(1), MWNumericArray))(idx)
            Next idx

            Console.WriteLine("Frequency:{0}{1}{2}", Chr(10), resultArray, Chr(10))

            For idx = 1 To numElements
                resultArray(idx) = (CType(argsOut(2), MWNumericArray))(idx)
            Next idx

            Console.WriteLine("Power Spectral Density:{0}{1}{2}", Chr(10), resultArray, Chr(10))

            ' Create a new plotter object
            Dim plotter As Plotter = New Plotter

            ' Plot the fft and power spectral density for the data array
            plotter.plotfft(argsOut(0), argsOut(1), argsOut(2))

            Console.ReadLine()  ' Wait for user to exit application

        Catch exception As Exception
            Console.WriteLine("Error: {0}", exception)

        End Try
    End Sub
#End Region

      End Class
End Namespace
```

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
- Uses `MWNumericArray` to handle data conversion

Note For complete reference information about the MWArray class hierarchy, see the MWArray Class Library Reference (available online only).

- Instantiates a SignalAnalyzer object
- Calls the computefft method, which computes the FFT, frequency, and the spectral density
- Instantiates a Plotter object
- Calls the plotfft method, which plots the data
- Uses a try/catch block to handle exceptions

The following statements

```
Dim data As MWNumericArray = New MWNumericArray_
    (MWArrayComplexity.Real, MWNumericType.Double, numSamples)
...
Dim resultArray As MWNumericArray = New MWNumericArray_
    (MWArrayComplexity.Complex, MWNumericType.Double, numElements)
```

show how to use the MWArray class library to construct the necessary data types.

The following statement

```
Dim signalAnalyzer As SignalAnalyzer = New SignalAnalyzer
```

creates an instance of the class SignalAnalyzer, and the following statement

```
Dim argsOut() As MWArray = signalAnalyzer.computefft
               (3, data, MWArray.op_Implicit(interval))
```

calls the method computefft and request three outputs.

2 Build the SpectraDemoApp application using Visual Studio .NET.

a. The SpectraDemoVBApp directory contains a Visual Studio .NET project file for this example. Open the project in Visual Studio .NET

by double-clicking `SpectraDemoVBApp.vbproj` in Windows Explorer. You can also open it from the MATLAB desktop by right-clicking **SpectraDemoVBApp.vbproj > Open Outside MATLAB**.

b. If necessary, add a reference to the `MWArray` component, which is `*matlabroot*\bin\win32\MWArray.dll`.

c. If necessary, add (or update the location of) a reference to the `SpectraDemo` component which you built in a previous step. (The component, `SpectraDemo.dll`, is in the `\SpectraExample\SpectraDemoComp\distrib` subdirectory of your work area.)

3 Build and run the application in Visual Studio .NET.

MatrixMath Example (Visual Basic)

To create the component for this example, see the first few steps in "Matrix Math Example" on page 4-21. Then create a Visual Basic application as follows.

1 The sample application for this example is in:

   matlabroot\toolbox\dotnetbuilder\Examples*VSversionnumber*\MatrixMathExample
   \MatrixMathDemoVBApp\MatrixMathDemoApp.vb.

   The program listing is shown here.

   ### MatrixMathDemoApp.vb

```
' *******************************************************************************
'
' MatrixMathDemoApp.vb
'
' This file is an example application for the MATLAB Builder for .NET product.
'
' Copyright 2001-2006 The MathWorks, Inc.
'
' *******************************************************************************

Imports System

Imports MathWorks.MATLAB.NET.Utility
Imports MathWorks.MATLAB.NET.Arrays

Imports MatrixMathDemoComp


<Assembly: NativeGC(False)>  ' Disable Automatic native memory management

Namespace MathWorks.Demo.MatrixMathApp

    ' <summary>
    ' This application computes cholesky, LU, and QR factorizations of a finite difference matrix of order N.
    ' The order is passed into the application on the command line.
```

```
    ' </summary>
    ' <remarks>
    ' Command Line Arguments:
    ' <newpara></newpara>
    ' args[0] - Matrix order(N)
    ' <newpara></newpara>
    ' args[1] - (optional) sparse; Use a sparse matrix
    ' </remarks>
    Class MatrixMathDemoApp

#Region " MAIN "

        ' <summary>
        ' The main entry point for the application.
        ' </summary>
        Shared Sub Main(ByVal args() As String)

            Dim makeSparse As Boolean = True
            Dim matrixOrder As Integer = 4

            Dim matrix As MWNumericArray = Nothing ' The matrix to factor

            Dim argOut As MWArray = Nothing   ' Stores single factorization result
            Dim argsOut() As MWArray = Nothing  ' Stores multiple factorization results

            Try
                ' If no argument specified, use defaults
                If (0 <> args.Length) Then
                    'Convert matrix order
                    matrixOrder = System.Int32.Parse(args(0))

                    If (0 > matrixOrder) Then
                        Throw New ArgumentOutOfRangeException("matrixOrder", matrixOrder, _
                                                              "Must enter a positive integer for the matrix order(N)")
                    End If

                    makeSparse = ((1 < args.Length) AndAlso (args(1).Equals("sparse")))
                End If

                ' Create the test matrix.  If the second argument is "sparse", create a sparse matrix.
```

```
matrix = IIf(makeSparse, _
MWNumericArray.MakeSparse_
   (matrixOrder, matrixOrder, MWArrayComplexity.Real, (matrixOrder + (2 * (matrixOrder - 1)))), _
New MWNumericArray_
   (MWArrayComplexity.Real, MWNumericType.Double, matrixOrder, matrixOrder))

' Initialize the test matrix
For rowIdx As Integer = 1 To matrixOrder
    For colIdx As Integer = 1 To matrixOrder
        If rowIdx = colIdx Then
            matrix(rowIdx, colIdx) = New MWNumericArray(2.0)
        ElseIf colIdx = rowIdx + 1 Or colIdx = rowIdx - 1 Then
            matrix(rowIdx, colIdx) = New MWNumericArray(-1.0)
        End If
    Next colIdx
Next rowIdx

' Create a new factor object
Dim factor As Factor = New Factor

' Print the test matrix
Console.WriteLine("Test Matrix:{0}{1}{2}", Chr(10), matrix, Chr(10))

' Compute and print the cholesky factorization using the single output syntax
argOut = factor.cholesky(matrix)

Console.WriteLine("Cholesky Factorization:{0}{1}{2}", Chr(10), argOut, Chr(10))

' Compute and print the LU factorization using the multiple output syntax
argsOut = factor.ludecomp(2, matrix)

Console.WriteLine("LU Factorization:{0}L Matrix:{1}{2}{3}U Matrix:{4}{5}{6}",_
                  Chr(10), Chr(10), argsOut(0), Chr(10), Chr(10), argsOut(1), Chr(10))

MWNumericArray.DisposeArray(argsOut)

' Compute and print the QR factorization
argsOut = factor.qrdecomp(2, matrix)

Console.WriteLine("QR Factorization:{0}Q Matrix:{1}{2}{3}R Matrix:{4}{5}{6}", _
```

```
                           Chr(10), Chr(10), argsOut(0), Chr(10), Chr(10), argsOut(1), Chr(10))

                Console.ReadLine()

            Catch exception As Exception

                Console.WriteLine("Error: {0}", exception)

            Finally

                ' Free native resources
                If Not (matrix Is Nothing) Then
                    matrix.Dispose()
                End If
                If Not (argOut Is Nothing) Then
                    argOut.Dispose()
                End If

                MWNumericArray.DisposeArray(argsOut)
            End Try
        End Sub
#End Region
    End Class
End Namespace
```

The statement

```
Dim factor As Factor = New Factor
```

creates an instance of the class `Factor`.

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

```
argOut = factor.cholesky(matrix)


argsOut = factor.ludecomp(2, matrix)

...
```

```
argsOut = factor.qrdecomp(2, matrix)
```

Note See “Understanding the MatrixMathDemo Program” on page 4-28 for more details about the structure of this program.

---

2. Build the `MatrixMathDemoApp` application using Visual Studio .NET.

   a. The `MatrixMathDemoVBApp` directory contains a Visual Studio .NET project file for this example. Open the project in Visual Studio .NET by double-clicking `MatrixMathDemoVBApp.vbproj` in Windows Explorer. You can also open it from the MATLAB desktop by right-clicking **MatrixMathDemoVBApp.vbproj > Open Outside MATLAB**.

   b. If necessary, add a reference to the `MWArray` component, which is *`matlabroot`*`\bin\win32\MWArray.dll.`

   c. If necessary, add (or update the location of) a reference to the `MatrixMathDemoComp` component which you built in a previous step. (The component, `MatrixMathDemo.dll`, is in the `\MatrixMathExample\MatrixMathDemoComp\distrib` subdirectory of your work area.)

3. Build and run the application in Visual Studio .NET.

6

Troubleshooting

This chapter provides some solutions to common problems encountered using MATLAB Builder for .NET.

Troubleshooting the Build Process (p. 6-2)	Solutions for common problems that occur during the build process
Failure to Find a Required File (p. 6-3)	Solutions to problems when files cannot be found
Diagnostic Messages (p. 6-4)	Diagnostic messages with suggestions about their cause

Troubleshooting the Build Process

If you encounter problems during the build process, you can

- "View the Latest Build Log" on page 6-2
- "Generate Verbose Output" on page 6-2

View the Latest Build Log

To view the log of your most recent build process, open the build log, which is generated in the intermediate directory for your project. By default the intermediate directory for a project is *project_directory/projectname_without_ext/src*.

Generate Verbose Output

Telling the Deployment Tool to generate verbose output provides a more detailed log of each build. These details can assist you in determining the cause of problems you encounter.

To enable verbose output during builds, select **Show verbose output** in the Deployment Tool window.

Failure to Find a Required File

If your application generates a diagnostic message indicating that a module cannot be found, it could be that the MCR is not located properly on your path, or that the CTF file is not in the proper directory. How to fix this problem depends on whether it occurs on a development machine (where you are using .NET Builder to create a component) or target machine (where you are trying to use the component in your application). The required locations are as follows for MCR and CTF according to development versus target machines.

Required Locations to Develop and Use Components

Kind of File	Required Location on Development Machine	Required Location on Target Machine
MCR	Make sure that `matlabroot\bin\win32` appears on your system path ahead of any other MATLAB installations. (`matlabroot` is your root MATLAB directory.)	Verify that `mcr_root\ver\runtime\win32` appears on your system path. (`mcr_root` is your root MCR directory) and `ver` represents the MCR version number.
CTF	Verify that the CTF file is in the same directory as your program's executable file.	

Diagnostic Messages

The following table shows diagnostic messages you might encounter, probable causes for the message, and suggested solutions.

Note MATLAB Builder for .NET uses the MATLAB Compiler to generate components. This means that you might see diagnostic messages from the MATLAB Compiler. See "Compile-Time Errors" in the MATLAB Compiler documentation for more information about those messages.

See the following table for information about some diagnostic messages.

Diagnostic Messages and Suggested Solutions

Message	Probable Cause	Suggested Solution
`LoadLibrary ("`*`component_name`*`_1_0.dll") failed - The specified module could not be found.`	You may get this error message while registering the project DLL from the DOS prompt. This usually occurs if MATLAB is not on the system path.	See "Failure to Find a Required File" on page 6-3.
	You might also get this error if you try to deploy your component without adding the path for the DLL to the system path on the target machine.	On the target machine where the COM component is to be used: **1** Use the `extractCTF.exe` utility to decompress the `.ctf` file generated by .NET Builder when you built the COM component. **2** Look at the files in the CTF, and note the path for the DLL. **3** Add this path to the system path. See the MATLAB Compiler documentation for more information about `extractctf.exe`.
`MBUILD.BAT: Error: The chosen compiler does not support building COM objects.`	The chosen compiler does not support building COM objects.	Rerun `mbuild -setup` and choose a supported compiler.

Diagnostic Messages and Suggested Solutions (Continued)

Message	Probable Cause	Suggested Solution
`Error in` *`component_name`*`.`*`class_name`*`.x: Error getting data conversion flags.`	This is often caused by `mwcomutil.dll` not being registered.	**1** Open a DOS window. **2** Change directories to *`matlabroot`*`\bin\win32`. **3** Run the following command: `mwregsvr mwcomutil.dll` (*`matlabroot`* is your root MATLAB directory.)
`Error in VBAProject: ActiveX component can't create object.`	• Project DLL is not registered. • An incompatible MATLAB DLL exists somewhere on the system path.	If the DLL is not registered, **1** Open a DOS window. **2** Change directories to *`projectdir`*`\distrib`. **3** Run the following command: `mwregsvr` *`projectdll`*`.dll` (*`projectdir`* represents the location of your project files).

Diagnostic Messages and Suggested Solutions (Continued)

Message	Probable Cause	Suggested Solution
`Error in VBAProject: Automation error The specified module could not be found.`	This usually occurs if MATLAB is not on the system path.	See "Failure to Find a Required File" on page 6-3.
`QueryInterface for interface <COM OBJECT NAME> failed.`	You might be using the incorrect number and/or type of function parameters to call into your COM object.	Function calls to COM objects that encapsulate MATLAB functions must have the same number and data type of arguments as the COM object. In general: • Use a Variant data type for the return type of the COM object. • Use doubles as default numeric input parameters (rather than integers) You might also use development tools such as OLEVIEW and Object Browser, which ship with Microsoft Visual Studio and Microsoft Visual Basic, respectively, to verify the expected function signature of the TypeLib for the COM Object.

7

Reference Information for .NET

Requirements for MATLAB Builder for .NET (p. 7-2)	Software requirements for using MATLAB Builder for .NET
MATLAB Builder for .NET User Interface (p. 7-4)	Details about the windows, dialog boxes, menus, and buttons
Data Conversion Rules (p. 7-9)	Details about the way that MATLAB Builder for .NET handles data
Overview of Data Conversion Classes (p. 7-12)	Summary information about `MWArray` classes
MWArray Class Specification (p. 7-20)	Description of class information

Requirements for MATLAB Builder for .NET

- “System Requirements” on page 7-2
- “Compiler Requirements” on page 7-2
- “Limitations and Restrictions” on page 7-3

System Requirements

System requirements and restrictions on use for MATLAB Builder for .NET are as follows:

- All requirements for the MATLAB Compiler; see “Installation and Configuration” in the MATLAB Compiler documentation.
- .NET Framework 1.1 or 2.0 must be installed.
- Either Visual Studio 2003, Visual Studio 2005, or the corresponding .NET Framework SDK must be available on the target machine.

Compiler Requirements

You must have MATLAB and MATLAB Compiler installed to install MATLAB Builder for .NET.

MATLAB Builder for .NET is available only on Windows.

For an up-to-date list of all the compilers supported by MATLAB and the MATLAB Compiler, see the MathWorks Technical Support Department’s Technical Notes at `http://www.mathworks.com/support/tech-notes/1600/1601.html`.

Note Before you use MATLAB Builder for .NET to build COM components, you must run `mbuild -setup` to configure your C/C++ compiler to work with the MATLAB Compiler.

Limitations and Restrictions

In general, limitations and restrictions on the use of .NET Builder are the same as those for the MATLAB Compiler. See the MATLAB Compiler documentation for details.

MATLAB Builder for .NET User Interface

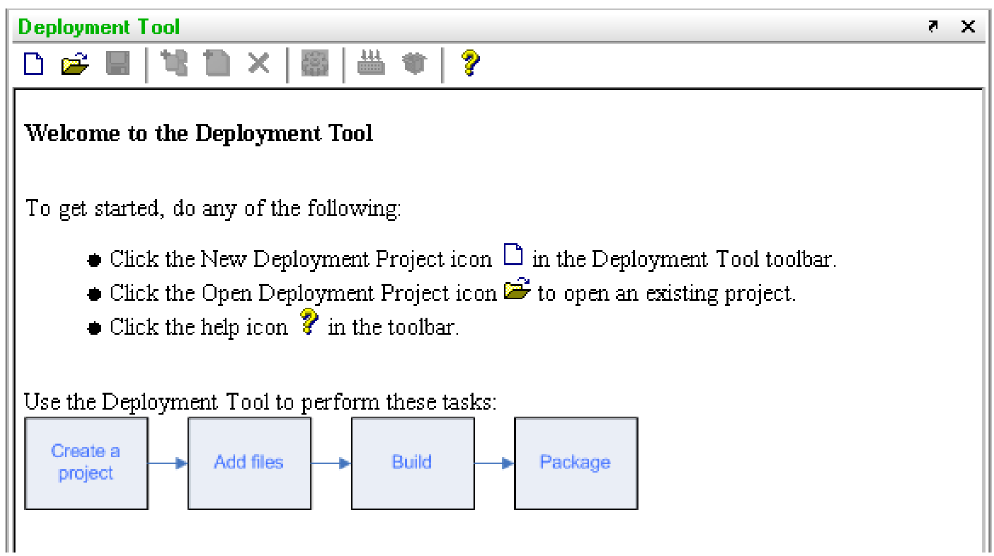
Use the .NET Builder graphical user interface (GUI) to create .NET classes that encapsulate your M-file functions. You can build and package .NET components that support the classes you create.

Similarly, you can also use the GUI to create and package COM components that encapsulate M-code.

To start the application, run the following command at the MATLAB prompt:

```
deploytool
```

The Deployment Tool opens as shown.



Note that the Deployment Tool window can be docked or undocked.

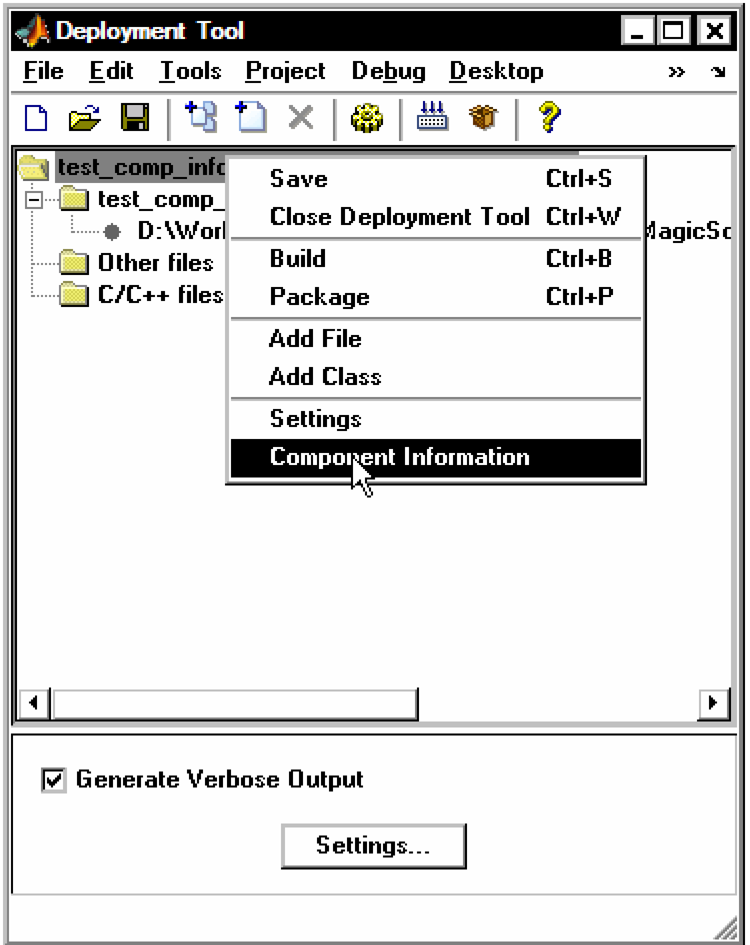
The Deployment Tool toolbar has the following icons.

Toolbar Icons

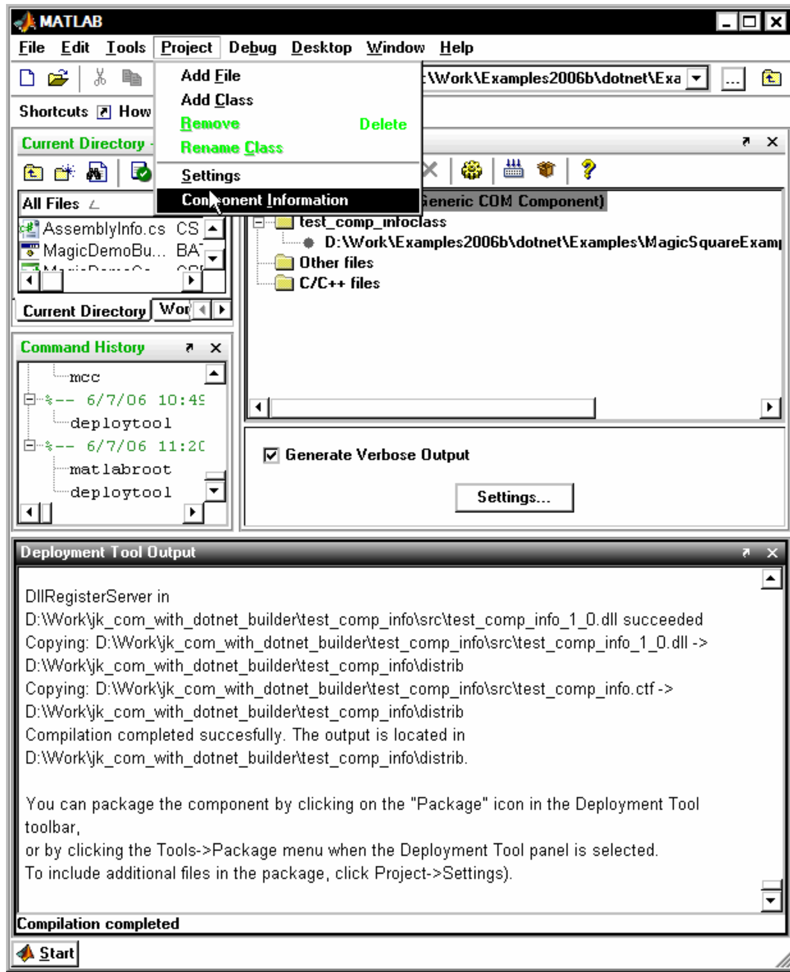
Name of Toolbar Icon	Icon	Click to...
New Project		Create a new deployment project.
Open Project		View projects and select one to open.
Save Project		Save the current project, including all files and settings.
Add Class (only for components that contain classes)		Open the Add Class dialog box, where you can specify the name of a new class to be created as part of the current project.
Remove		Remove the selected class folder or the selected files from the project.
Build		Build the components specified by the project, displaying the build process in the **Deployment Tool Output** pane.
Package		Create a self-extracting executable (Windows) or .zip file (UNIX) that contains the files needed to use the component in an application.
Settings		Change settings for the project. You can improve performance by changing settings, such as whether to exclude the MCR or change the search path when building.
Help		View a quick start and steps for using the Deployment Tool.

Component Information Dialog Box

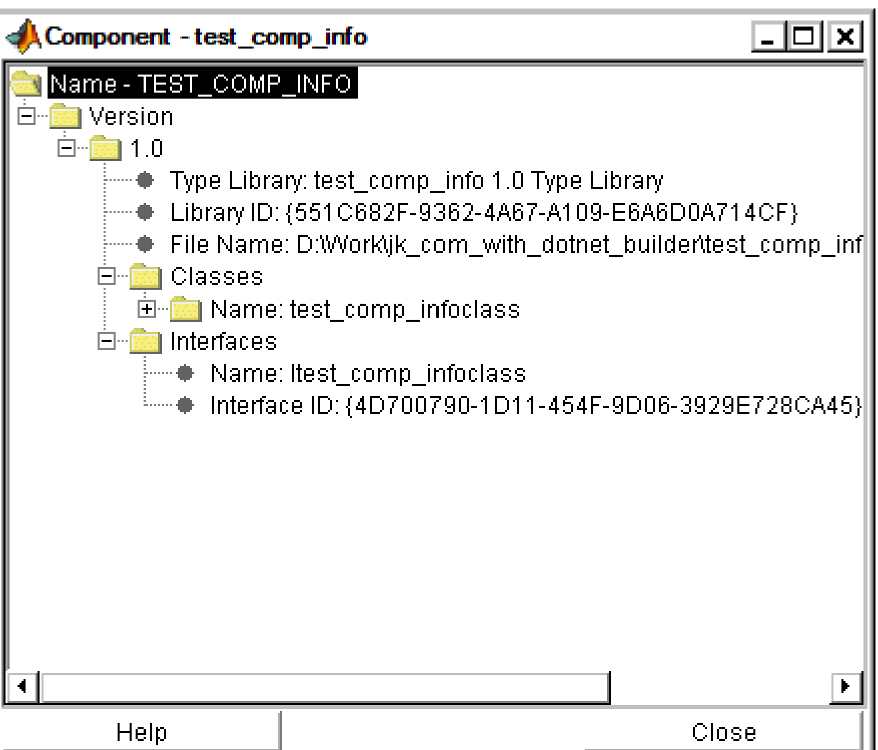
To examine component information for COM components created with MATLAB Builder for .NET, right-click the project in the Deployment Tool and select **Component Information**, as shown:



Alternatively, you can select **Project > Component Information** from the MATLAB desktop menu bar, with the project selected in Deployment Tool, as shown:



After you select the **Component Information** menu command, the following dialog box appears; the following figures shows a sample of the information provided:


Component - test_comp_info
Name - TEST_COMP_INFO
Version
1.0
Type Library: test_comp_info 1.0 Type Library
Library ID: {551C682F-9362-4A67-A109-E6A6D0A714CF}
File Name: D:\Work\jk_com_with_dotnet_builder\test_comp_inf
Classes
Name: test_comp_infoclass
Interfaces
Name: Itest_comp_infoclass
Interface ID: {4D700790-1D11-454F-9D06-3929E728CA45}
Help
Close

Data Conversion Rules

- “Managed Types to MATLAB Arrays” on page 7-9
- “MATLAB Arrays to Managed Types” on page 7-9
- “Character and String Conversion” on page 7-10
- “Unsupported MATLAB Array Types” on page 7-11

Managed Types to MATLAB Arrays

The following table lists the data conversion rules used when converting native .NET types to MATLAB arrays.

Note The conversion rules listed in these tables apply to scalars, vectors, matrices, and multidimensional arrays of the native types listed.

Conversion Rules: Managed Types to MATLAB Arrays

<table>
<tr><th>Native .NET Type</th><th>MATLAB Array</th><th>Comments</th></tr>
<tr><td><code>System.Double</code></td><td><code>double</code></td><td>—</td></tr>
<tr><td><code>System.Float</code></td><td><code>single</code></td><td rowspan="5">Available only when the <code>makeDouble</code> constructor argument is set to <code>false</code>. The default is <code>true</code> which creates a MATLAB <code>double</code> type.</td></tr>
<tr><td><code>System.Int64</code></td><td><code>int64</code></td></tr>
<tr><td><code>System.Int32</code></td><td><code>int32</code></td></tr>
<tr><td><code>System.Int16</code></td><td><code>int16</code></td></tr>
<tr><td><code>System.Byte</code></td><td><code>int8</code></td></tr>
<tr><td><code>System.String</code></td><td><code>char</code></td><td></td></tr>
<tr><td><code>System.Boolean</code></td><td><code>logical</code></td><td></td></tr>
</table>

MATLAB Arrays to Managed Types

The following table lists the data conversion rules used when converting MATLAB arrays to native .NET types.

Note The conversion rules apply to scalars, vectors, matrices, and multidimensional arrays of the listed MATLAB types.

Conversion Rules: MATLAB Arrays to Managed Types

MATLAB Type	.NET Type (Primitive)	.NET Type (Class)	Comments
`cell`	N/A	`MWCellArray`	Cell and struct arrays have no corresponding .NET type.
`structure`	N/A	`MWStructArray`	
`char`	`System.String`	`MWCharArray`	
`double`	`System.Double`	`MWNumericArray`	Default is type double.
`single`	`System.Float`	`MWNumericArray`	Not supported
`int64`	`System.Int64`	`MWNumericArray`	
`int32`	`System.Int32`	`MWNumericArray`	
`int16`	`System.Int16`	`MWNumericArray`	
`uint8`	`System.Byte`	`MWNumericArray`	
`logical`	`System.Boolean`	`MWLogicalArray`	
Function handle	N/A	N/A	
Object	N/A	N/A	

Character and String Conversion

A native .NET string is converted to a `1`-by-*N* MATLAB character array, with *N* equal to the length of the .NET string.

An array of .NET strings (`string[]`) is converted to an *M*-by-*N* character array, with *M* equal to the number of elements in the string (`[]`) array and *N* equal to the maximum string length in the array.

Higher dimensional arrays of `String` are similarly converted.

In general, an *N*-dimensional array of `String` is converted to an *N*+1 dimensional MATLAB character array with appropriate zero padding where supplied strings have different lengths.

Unsupported MATLAB Array Types

The MATLAB .NET Builder does not support the following MATLAB array types because they are not CLS-compliant:

- `int8`
- `uint16`
- `uint32`
- `uint64`

Overview of Data Conversion Classes

The following sections provide an overview of the data conversion classes.

Note For complete reference information about the `MWArray` class hierarchy, see the MWArray Class Library Reference (available online only).

- "Overview of Classes" on page 7-12
- "Returning Data from MATLAB to Managed Code" on page 7-13
- "Example of MWNumericArray in a .NET Application" on page 7-13
- "Interfaces Generated by .NET Builder" on page 7-13

Overview of Classes

The data conversion classes are

```
MWArray
MWIndexArray
MWCellArray
MWCharacterArray
MWLogicalArray
MWNumericArray
MWStructArray
```

`MWArray` and `MWIndexArray` are abstract classes. The other classes represent the standard MATLAB array types: cell, character, logical, numeric, and struct. Each class provides constructors and a set of properties and methods for creating and accessing the state of the underlying MATLAB array.

There are some data types (cell arrays, structure arrays, and arrays of complex numbers) commonly used in MATLAB that are not available as native .NET types. To represent these data types you must create an instance of either`MWCellArray`, `MWStructArray`, or`MWNumericArray`.

Returning Data from MATLAB to Managed Code

All data returned from a MATLAB function to a .NET method is represented as an instance of the appropriate `MWArray` subclass. For example, a MATLAB cell array is returned as an `MWCellArray` object.

Return data is *not* automatically converted to a managed array. If you need to get the corresponding managed array type, call the `ToArray` method, which converts a MATLAB array to the appropriate native data type, except for cell and struct arrays.

Example of MWNumericArray in a .NET Application

Here is a code fragment that shows how to convert a `double` value (`5.0`) to a `MWNumericArray` type:

```
MWNumericArray arraySize = 5.0;
magicSquare = magic.MakeSqr(arraySize);
```

After the `double` value is converted and assigned to the variable `arraySize`, you can use the `arraySize` argument with the a MATLAB-based method without further conversion. In this example, the MATLAB-based method is `magic.MakeSqr(arraySize)`.

Interfaces Generated by .NET Builder

For each MATLAB function that you specify as part of a .NET component, .NET Builder generates an API based on the MATLAB function signature, as follows:

- A *single output* signature that assumes that only a single output is required and returns the result in a single `MWArray` rather than an array of `MWArrays`.
- A *standard* signature that specifies inputs of type `MWArray` and return values as an array of `MWArray`.
- A *feval* signature that includes both input and output arguments in the argument list rather than returning outputs as a return value. Output arguments are specified first, followed by the input arguments.

Single Output API

Note Typically you use the single output interface for MATLAB functions that return a single argument. You can also use the single output interface when you want to use the output of a function as the input to another function.

For each MATLAB function, .NET Builder generates a wrapper class that has overloaded methods to implement the various forms of the generic MATLAB function call. The single output API for a MATLAB function returns a single `MWArray` value.

For example, the following table shows a generic function `foo` along with the API that .NET Builder generates for its several forms.

Generic MATLAB function	`function [Out1, Out2, ..., varargout] =` `  foo(In1, In2, ..., InN, varargin)`
API if there are no input arguments	`public MWArray foo()`

API if there are one or more input arguments	`public MWArray foo(`
	`MWArray` *`In1,`*
	`MWArray` *`In2`*
	`...`
	`MWArray` *`inN`*`)`

API if there are optional arguments	`public MWArray foo(`
	`MWArray` *`In1`*`,`
	`MWArray` *`In2,`*
	`     ...,`
	`MWArray` *`inN`*
	`params MWArray[]` *`varargin`*
	`)`

In the example, the input arguments*`In1,In2`*, and *`inN`* are of type `MWArray` objects.

Similarly, in the case of optional arguments, the `params` arguments are of type MWArray. (The `varargin` argument is similar to the `varargin` function in MATLAB — it allows the user to pass a variable number of arguments.)

Note When you call a class method in your .NET application, specify all required inputs first, followed by any optional arguments.

Functions having a single integer input require an explicit cast to type `MWNumericArray` to distinguish the method signature from a standard interface signature that has no input arguments.

Standard API

Typically you use the standard interface for MATLAB functions that return an multiple output values.

The standard calling interface returns an array of `MWArray` objects rather than a single array object.

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.

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

API if there are no input arguments	`public MWArray[] foo(`
	`int` *`numArgsOut`*
	`)`

API if there is one input argument	`public MWArray [] foo(`
	`int` *`numArgsOut`*`,`
	`MWArray` *`In1`*
	`)`

<table>
<tr><td>API if there are two to N input arguments</td><td><pre>public MWArray[] foo(
int numArgsOut,
MWArray In1,
MWArray In2,
...
MWArray InN
)</pre></td></tr>
<tr><td>API if there are optional arguments, represented by the <code>varargin</code> argument</td><td><pre>public MWArray[] foo(
int numArgsOut,
 MWArray in1,
 MWArray in2,
 ...,
MWArray InN,
params MWArray[] varargin
)</pre></td></tr>
</table>

Details about the arguments for these samples of standard signatures are shown in the following table:

Argument	Description	Details About this Argument
numArgsOut	Number of outputs	An integer indicating the number of outputs you want the method to return. The value of *numArgsOut* must be less than or equal to the MATLAB function `nargout`. The `numArgsOut` argument must always be the first argument in the list
In1, In2, ...InN	Required input arguments	All arguments that follow *numArgsOut* in the argument list are inputs to the method being called. Specify all required inputs first. Each required input must be of type `MWArray` or one of its derived types.

Argument	Description	Details About this Argument
varargin	Optional inputs	You can also specify optional inputs if your M-code uses the `varargin` input: list the optional inputs, or put them in an `MWArray[]` argument, placing the array last in the argument list.
`Out1, Out2, ... OutN`	Output arguments	With the standard calling interface, all output arguments are returned as an array of `MWArray`s.

feval API

In addition to the methods in the single API and the standard API, in most cases, .NET Builder produces an additional overloaded method. If the original M-code contains no output arguments, then .NET Builder will not generate the `feval` method interface.

For a function with the following structure

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

.NET Builder generates the following API, known as the *feval interface*.

```
public void foo
              (int numArgsOut,
               ref MWArray [] ArgsOut,
               MWArray[] ArgsIn)
```

where the arguments are as follows:

`numArgsOut`	Number of outputs	Same as standard interface An integer indicating the number of outputs you want to return. This number generally matches the number of output arguments that follow. The `varargout` array counts as just one argument, if present.
`ref MWArray [] ArgsOut`	Output arguments	Following `numArgsOut` are all the outputs of the original M-code, each listed in the same order as they appear on the left-hand side of the original M-code. A `ref` attribute prefaces all output arguments indicating that these arrays are passed by reference. If *`numArgsOut`* is greater than the number of output arguments listed, the remaining arguments are returned in the output argument array.
`MWArray[] ArgsIn`	Input arguments	`MWArray` types or a supported .NET primitive type. When you pass an instance of an `MWArray` type, the underlying MATLAB array is passed directly to the called function. Managed types are first converted to `MWArray` types.

Return Value for the feval Interface. The return value for the feval interface is passed as an array of `MWArray`. In most cases this return value is a zero length array, and can be ignored. (A zero-length array is used so that the return value is never null.)

In the case where *`numArgsOut`* is greater than the number of the output arguments supplied to the function, the remaining outputs are returned in

the output array. Output arguments returned in this array are always passed as instances of type `MWArray`.

MWArray Class Specification

For complete reference information about the `MWArray` class hierarchy, see the MWArray Class Library Reference (available online only).

See "Specifying Component Assembly and Namespace" on page 3-3 for information about referencing the classes in your .NET programming environment.

Functions — Alphabetical List

componentinfo

Purpose

Query system registry about COM component created with MATLAB Builder for .NET

Syntax

```
info = componentinfo
info = componentinfo(component_name)
info = componentinfo(component_name, major_revision_number)
info = componentinfo(component_name, major_revision_number,
   minor_revision_number)
```

Arguments

component_name	MATLAB string providing the name of a COM component created by MATLAB Builder for .NET. Names are case sensitive. If this argument is not supplied, the function returns information on all installed components.
major_revision_number	Component major revision number. If this argument is not supplied, the function returns information on all major revisions.
minor_revision_number	Component minor revision number. Default value is `0`.

Description

`info = componentinfo` returns information for all components installed on the system.

`info = componentinfo(`*`component_name`*`)` returns information for all revisions of *`component_name`*.

`info = componentinfo(`*`component_name`*`, `*`major_revision_number`*`)` returns information for the most recent minor revision corresponding to *`major_revision_number`* of *`component_name`*.

`info = componentinfo(`*`component_name`*`, `*`major_revision_number`*`, `*`minor_revision_number`*`)` returns information for the specific major and minor version of *`component_name`*.

The return value is an array of structures representing all the registry and type information needed to load and use the component.

When you supply a component name, *major_revision_number* and *minor_revision_number* are interpreted as shown below.

Value	Information Returned
> 0	Information on a specific major and minor revision
0	Information on the most recent revision When omitted, *minor_revision_number* is assumed to be equal to 0.
< 0	Information on all versions

The information about a component has the fields shown in the following tables.

Registry Information Returned by componentinfo

Field	Description
Name	Component name
TypeLib	Component type library
LIBID	Component type library GUID
MajorRev	Major version number
MinorRev	Minor version number
FileName	Type library file name and path. Since all COM components created with .NET Builder have the type library bound into the DLL, this file name is the same as the DLL name and path.

Field	Description
Interfaces	An array of structures defining all interface definitions in the type library. Each structure contains: Name - Interface name IID - Interface GUID
CoClasses	Array of structures defining all COM classes in the component. Each structure contains: Name - Class name CLSID - GUID of the class ProgID - Version dependent program ID VerIndProgID - Version independent program ID InprocServer32 - Full name and path to DLL Methods - A structure containing function prototypes of all class methods defined for this interface. This structure contains four fields: IDL - An array of Interface Description Language function prototypes M - An array of MATLAB function prototypes C - An array of C-language function prototypes VB - An array of VBA function prototypes Properties - A cell array containing the names of all class properties. Events - A structure containing function prototypes of all events defined for this class. This structure contains four fields: IDL - An array of IDL (Interface Description Language) function prototypes. M - An array of MATLAB function prototypes. C - An array of C-Language function prototypes. VB - An array of VBA function prototypes

Usage

Use the `componentinfo` function to get information (such as class name, program id) to pass on to users of a component that you create.

The `componentinfo` function also provides a record of changes made to the registry on your development machine. This information might be useful for debugging if you run into problems.

Examples

Function Call	Description of Return Information
`Info = componentinfo`	Information for all installed components.
`Info = componentinfo('mycomponent')`	Information for all revisions of `mycomponent`.
`Info = componentinfo('mycomponent',1,0)`	Information for revision 1.0 of `mycomponent`.

deploytool

Purpose Open GUI for MATLAB Builder for .NET and MATLAB Compiler

Syntax

```
deploytool
```

Description The `deploytool` command displays the Deployment Tool dialog box, which is the graphical user interface (GUI) for MATLAB Builder for .NET and for MATLAB Compiler.

See "Creating a .NET Component" on page 1-4 to get started using the Deployment Tool to create .NET and COM components, and see the MATLAB Compiler documentation for information about using the Deployment Tool to create standalone applications and libraries.

See "MATLAB Builder for .NET User Interface" on page 7-4 for reference information about the GUI.

Creating a COM Component

Building a Deployable Application (p. 9-2)	How to create and package a COM component
Using the Command-Line Interface (p. 9-4)	How you can use the `mcc` command instead of the GUI to build COM objects
Executing MATLAB Functions via the World Wide Web (p. 9-7)	Special information about interfacing MATLAB code with the Internet

Building a Deployable Application

The steps to create a COM component are very similar to the steps described in "Creating a .NET Component" on page 1-4. Here is a brief summary of the steps:

1. If you have not already done so, execute the following command in MATLAB:

   ```
   mbuild -setup
   ```

   Be sure to choose a supported compiler. See "Compiler Requirements" on page 7-2.

2. Open the Deployment Tool dialog box.

   ```
   deploytool
   ```

3. Click the New Project button in the toolbar to open the New Project Settings dialog box.

4. Specify the name and location for the project.

5. Add files that you want to encapsulate by dragging them to the Deployment Tool or clicking the Add File button in the toolbar.

6. Optionally, add classes by clicking the Add Classes button in the toolbar.

7. Optionally, click the Settings button in the toolbar to specify various properties for building and packaging your component.

8. Save the project by clicking the Save Project button in the toolbar.

9. Build the project by clicking the Build button in the toolbar.

10. Package the project by clicking the Package button in the toolbar. The package is a self-extracting executable named `componentname.exe`.

Files in the Self-Extracting Executable

File	Purpose
componentname.ctf	Component Technology File (ctf) archive. This is a platform-dependent file that must correspond to the end user's platform.
componentname_projectversion	Component that encapsulates M-code
_install.bat	Script run by the self-extracting executable
MCRInstaller.exe	Self-extracting MATLAB Component Runtime library utility; platform-dependent file that must correspond to the end user's platform. MCRInstaller.exe installs MATLAB Component Runtime (MCR), which users of your component need to install on the target machine once per release.

11 Distribute the self-extracting executable to your users.

Using the Command-Line Interface

You can use the MATLAB command line interface instead of the GUI to create COM objects. Do this by issuing the `mcc` command with options. If you use `mcc`, you do not create a project.

Note See the MATLAB Compiler documentation for a complete description of the `mcc` command and its options.

The following table provides an overview of some `mcc` options related to components, along with syntax and examples of their usage.

Using the Command Line to Create COM Components

<table>
<tr><th>Action to Perform</th><th>mcc Option to Use</th><th>Description</th></tr>
<tr><td rowspan="3">Create component that has one class.</td><td><code>-W com</code></td><td>The <code>W</code> option with <code>com</code> as the type controls the generation of wrapper files, which you can use to support components.</td></tr>
<tr><td colspan="2">Syntax
<code>mcc -W</code>
<code>'com:<component_name>[,<class_name>[,<major>.<minor>]]'</code>

An unspecified <code><class_name></code> defaults to <code><component_name></code>, and an unspecified version number defaults to the latest version built or 1.0, if there is no previous version.</td></tr>
<tr><td colspan="2">Example
<code>mcc -W 'com:mycomponent,myclass,1.0' -T link:lib foo.m bar.m</code>

The example creates a COM component called <code>mycomponent</code>, which contains a single COM class named <code>myclass</code> with methods <code>foo</code> and <code>bar</code>, and a version of 1.0.</td></tr>
</table>

Using the Command Line to Create COM Components (Continued)

Action to Perform	mcc Option to Use	Description
Add additional classes to a COM component.	Not needed	A separate COM named `<class_name>` is created for each class argument that is passed. Following the `<class_name>` parameter is a comma-separated list of source files that are encapsulated as methods for the class.
	Syntax `class{<class_name>:[file, [file,...]]}`	

	Example
	`mcc -B 'ccom:mycomponent,myclass,1.0'`
	`foo.m bar.m class{myclass2:foo2.m, bar2.m}`
	The example creates a COM component named `mycomponent` with two classes: `myclass` has methods `foo` and `bar`, and `myclass2` has methods `foo2` and `bar2`. The version is version 1.0.	

Simplify the command line input for components.	`-B ccom:`	Uses the bundle file.
	Syntax `mcc -B '<filename>'[:<a1>,<a2>,...,<an>]`	
	Example `mcc -B 'ccom:mycomponent,myclass,1.0' foo.m bar.m`	

Using the Command Line to Create COM Components (Continued)

<table>
<tr><th>Action to Perform</th><th>mcc Option to Use</th><th>Description</th></tr>
<tr><td rowspan="2">Control how each COM class uses the MCR.</td><td><code>-S</code></td><td>By default, a new MCR instance is created for each instance of each COM class in the component. Use <code>-S</code> to change the default.

This option tells .NET Builder to create a single MCR is when the first COM class is instantiated. This MCR is reused and shared among all subsequent class instances, resulting in more efficient memory usage and eliminating the MCR startup cost in each subsequent class instantiation. When using <code>-S</code>, note that all class instances share a single MATLAB workspace and share global variables in the M-files used to build the component. This makes properties of a COM class behave as static properties instead of instance-wise properties.</td></tr>
<tr><td colspan="2">Example
<code>mcc -S -B 'ccom:mycomponent,myclass,1.0' foo.m bar.m</code>

The example creates a COM component called <code>mycomponent</code> containing a single COM class named <code>myclass</code> with methods <code>foo</code> and <code>bar</code>, and a version of 1.0.

When multiple instances of this class are instantiated in an application, only one MCR is initialized, and it is shared by each instance.</td></tr>
<tr><td rowspan="2">Create subdirectories needed for deployment and copy associated files to them.</td><td><code>-d</code></td><td>The <code>\src</code> and <code>\distrib</code> subdirectories are needed to package components.</td></tr>
<tr><td colspan="2">Syntax
<code>-d directoryname</code></td></tr>
</table>

Executing MATLAB Functions via the World Wide Web

You can facilitate access to MATLAB code through the World Wide Web by using MATLAB Builder for .NET to create a COM object that you access from a browser on Windows. There is currently no solution for non-Windows machines. The use of CGI scripts to interface MATLAB with the World Wide Web is explicitly prohibited by the license agreement. See section 4.8 in the license.

10

Programming with COM Components Created by MATLAB Builder for .NET

General Techniques (p. 10-3)	Describes the integration of COM components created with MATLAB Builder for .NET into programs
Registering and Referencing the Utility Library (p. 10-5)	How to register and reference the utilities you need in your program
Creating an Instance of a Class in Visual Basic (p. 10-6)	Describes two techniques for calling a class method
Calling the Methods of a Class Instance (p. 10-9)	Describes how you call the class methods to access the encapsulated M-functions
Calling a COM Object in a C++ Program (p. 10-12)	How to integrate a COM object into a C++ program
Adding Events to COM Objects (p. 10-15)	Describes how you can turn a MATLAB function into an event function
Passing Arguments (p. 10-19)	Describes how you can pass multiple arguments as a `varargin` array by creating a `Variant` array, assigning each element of the array to the respective input argument

Using Flags to Control Array Formatting and Data Conversion (p. 10-21)	Describes array formatting and data conversion flags.
Using MATLAB Global Variables (p. 10-28)	Describes class properties, which allow an object to retain an internal state between method calls.
Blocking Execution of a Console Application that Creates Figures (p. 10-31)	How to handle interaction in a console-based program that creates MATLAB figures
Obtaining Registry Information (p. 10-34)	How to use MATLAB function `componentinfo` to query the system registry for any installed COM components created with MATLAB Builder for .NET
Handling Errors During a Method Call (p. 10-36)	Describes the Visual Basic exception handling capability.

General Techniques

After you package and install a COM component created by MATLAB Builder for .NET, you can access the component in any program that supports COM, such as Visual Basic, Visual C++, or Visual C#.

Your code module must do the following:

- Load the components created by .NET Builder
  - “Registering and Referencing the Utility Library” on page 10-5
  - “Creating an Instance of a Class in Visual Basic” on page 10-6
- Call methods of the component class
  - “Calling the Methods of a Class Instance” on page 10-9
  - “Calling a COM Object in a C++ Program” on page 10-12
  - “Adding Events to COM Objects” on page 10-15
  - “Obtaining Registry Information” on page 10-34
- Deal with data conversion and parameter passing
  - “Passing Arguments ” on page 10-19
  - “Using Flags to Control Array Formatting and Data Conversion” on page 10-21
  - “Using MATLAB Global Variables” on page 10-28
- Process errors
  - “Handling Errors During a Method Call” on page 10-36

Note These topics provide general information on how to integrate COM components created with .NET Builder into your COM-compliant programs. The presentation focuses on the special programming techniques needed for components based on MATLAB and generated by .NET Builder. It assumes that you have a working knowledge of the programming language used in these programs.

For information about programming with COM objects in Microsoft Visual Studio, see articles in the MSDN Library, such as *Calling COM Components from .NET Clients*.

Registering and Referencing the Utility Library

The `MWComUtil` library provided with the MATLAB Builder for .NET is freely distributable. The `MWComUtil` library includes seven classes and three enumerated types. These utilities are required for array processing, and they provide type definitions used in data conversion.

The library is contained in the file `mwcomutil.dll`. It must be registered once on each machine that uses components created with .NET Builder.

Register the `MWComUtil` library at the DOS command prompt with the command:

```
mwregsvr mwcomutil.dll
```

To use the types in the library, make sure that you reference the `MWComUtil` library in your current project:

1. Click **Tools > References**.

2. Select **MWComUtil 7.5 Type Library**.

Creating an Instance of a Class in Visual Basic

Before calling a class method that encapsulates MATLAB functions, you must create an instance of the class. You can do this in Visual Basic using the following techniques.

- Using the "CreateObject Function" on page 10-6
- Using the "Visual Basic New Operator" on page 10-7
- "Declaring a Reusable Class Instance" on page 10-8

Each technique has advantages and disadvantages.

For an example of creating a class instance in Visual C++, see "Calling a COM Object in a C++ Program" on page 10-12.

CreateObject Function

This method uses the Visual Basic application program interface (API) `CreateObject` function to create an instance of the class.

1. Dimension a variable of type `Object` to hold a reference to the class instance.

2. Call `CreateObject` with the Program ID (`ProgID`) for the class as an argument.

Here is a programming example:

```
Function foo(x1 As Variant, x2 As Variant) As Variant
       Dim aClass As Object

       On Error Goto Handle_Error
       aClass = CreateObject("mycomponent.myclass.1_0")
       ' (call some methods on aClass)
       Exit Function
Handle_Error:
   foo = Err.Description
End Function
```

Visual Basic New Operator

This method uses the Visual Basic `New` operator on a variable explicitly dimensioned as the class to be created.

1. Make sure that you reference the type library containing the class in the current Visual Basic project.
   a. Open the Visual Basic editor.
   b. Click **Project > References > Available References**.
   c. Select the necessary type library.
2. Dimension the class instance.
3. Use `New` to instantiate the class with a particular name.

The following sample function, `foo`, shows how to use the `New` operator to create a class instance:

```
Function foo(x1 As Variant, x2 As Variant) As Variant
   Dim aClass As mycomponent.myclass

   On Error Goto Handle_Error
   Set aClass = New mycomponent.myclass
   ' (call some methods on aClass)
   Exit Function
Handle_Error:
   foo = Err.Description
End Function
```

In this example, the class instance could be dimensioned as simply `myclass`. The full declaration in the form `<component-name>.<class-name>` guards against name collisions that could occur if other libraries in the current project contain types named `myclass`.

Advantages of Each Technique

Both techniques (using `CreateObject` and using `New`) are equivalent in the way they function, but each has different advantages. The first technique does not require a reference to the type library in the Visual Basic project, while the second results in faster code execution. The second technique has

the added advantage of enabling **Auto-List-Members** and **Auto-Quick-Info** in the Visual Basic editor to help you work with your classes.

Declaring a Reusable Class Instance

In the previous examples, the class instance used to call the method is a local variable within a procedure. Thus a new class instance is created and destroyed for each call to the method. As an alternative, you can declare a single module-scoped class instance that is reused by all function calls. The next example shows this technique:

```
Dim aClass As mycomponent.myclass

Function foo(x1 As Variant, x2 As Variant) As Variant
   On Error Goto Handle_Error
   If aClass Is Nothing Then
      Set aClass = New mycomponent.myclass
   End If
   ' (call some methods on aClass)
   Exit Function
Handle_Error:
   foo = Err.Description
End Function
```

Calling the Methods of a Class Instance

After you create a class instance, you can call the class methods to access the encapsulated M-functions. MATLAB Builder for .NET uses a standard technique to map the original MATLAB function syntax to the method's argument list. This standard mapping technique is as follows:

- `nargout`

  When a method has output arguments, the first argument is always `nargout`, which is of type `Long`. This input parameter passes the normal MATLAB `nargout` parameter to the encapsulated function and specifies how many outputs are requested. Methods that do not have output arguments do not pass a `nargout` argument.

- Output parameters

  Following `nargout` are the output parameters listed in the same order as they appear on the left side of the original MATLAB function.

- Input parameters

  Next come the input parameters listed in the same order as they appear on the right side of the original MATLAB function.

For example, the most generic MATLAB function is

```
function [Y1, Y2, ..., varargout] = foo(X1, X2, ..., varargin)
```

This function maps directly to the following Visual Basic signature:

```
Sub foo(nargout As Long, _
        Y1 As Variant, _
        Y2 As Variant, _
        .
        .
        varargout As Variant, _
        X1 As Variant, _
        X2 As Variant, _
        .
        .
        varargin As Variant)
```

See "Calling Conventions" on page 12-22 for more details and examples of the standard mapping from MATLAB functions to COM class method calls.

Variant

All input and output arguments are typed as `Variant`, the default Visual Basic data type. The `Variant` type can hold any of the basic Visual Basic types, arrays of any type, and object references. See "Data Conversion Rules" on page 12-8 for details about the conversion of any basic type to and from MATLAB data types.

In general, you can supply any Visual Basic type as an argument to a class method, with the exception of Visual Basic User Defined Types (UDTs).

When you pass a simple `Variant` type as an output parameter, the called method allocates the received data and frees the original contents of the `Variant`. In this case it is sufficient to dimension each output argument as a single `Variant`. When an object type (like an Excel `Range`) is passed as an output parameter, the object reference is passed in both directions, and the object's `Value` property receives the data.

Examples of Passing Input and Output

The following examples show how to pass input and output parameters to .NET Builder component class methods in Visual Basic.

The first example is a function, `foo`, that takes two arguments and returns one output argument. The `foo` function dispatches a call to a class method that corresponds to a MATLAB function of the form `function y = foo(x1,x2)`.

```
Function foo(x1 As Variant, x2 As Variant) As Variant
   Dim aClass As Object
   Dim y As Variant

   On Error Goto Handle_Error
   Set aClass = CreateObject("mycomponent.myclass.1_0")
   Call aClass.foo(1,y,x1,x2)
   foo = y
   Exit Function
Handle_Error:
```

```
   foo = Err.Description
End Function
```

The second example rewrites the `foo` function as a subroutine:

```
Sub foo(Xout As Variant, X1 As Variant, X2 As Variant)
   Dim aClass As Object

   On Error Goto Handle_Error
   Set aClass = CreateObject("mycomponent.myclass.1_0")
   Call aClass.foo(1,Xout,X1,X2)
   Exit Sub
Handle_Error:
   MsgBox(Err.Description)
End Sub
```

Calling a COM Object in a C++ Program

The following steps show you how to create a COM object with MATLAB Builder for .NET and call that same object in a C++ program.

Note You must choose a Microsoft compiler to compile and use any COM object.

Using .NET Builder to Create the Object

Build the COM object as follows:

1. Start MATLAB.

2. If you have not already done so, execute the following command in MATLAB:

   ```
   mbuild -setup
   ```

   Be sure to choose a supported compiler. See "Compiler Requirements" on page 7-2.

3. Open the MATLAB Editor and create a file named `adddoubles.m` with the following M-code:

   ```
   function z=adddoubles(x,y)
   z=x+y;
   ```

4. In the MATLAB Command Window, issue the following command to open the Deployment Tool:

   ```
   deploytool
   ```

5. Create a project named `mycomponent` in any location you want.

6. Add `adddoubles.m` to the `mycomponentclass` folder. This means that the MATLAB function, `adddoubles`, will be a method in `mycomponentclass`

7. Click the Build icon in the Deployment Tool toolbar.

.NET Builder generates a self-registering COM object that you can use in your C++ code.

Using the Component in a C++ Program

Use the COM object you have created as follows:

1 Create a C++ program in a file named `matlab_com_example.cpp` with the following code:

```
#include <iostream>
using namespace std;

// include the following files generated by MATLAB Builder for .NET
#include "mycomponent\src\mycomponent_idl.h"
#include "mycomponent\src\mycomponent_idl_i.c"

int main() {
// Initialize argument variables
             VARIANT x, y, out1;
//Initialize the COM library
             HRESULT hr = CoInitialize(NULL);
//Create an instance of the COM object you created
             Imycomponentclass *pImycomponentclass;
             hr=CoCreateInstance
               (CLSID_mycomponentclass, NULL, CLSCTX_INPROC_SERVER, IID_Imycomponentclass,
                    (void **)&pImycomponentclass);
// Set the input arguments to the COM method
             x.vt=VT_R8;
             y.vt=VT_R8;
             x.dblVal=7.3;
             y.dblVal=1946.0;
// Access the method with arguments and receive the output out1
             hr=(pImycomponentclass -> adddoubles(1,&out1,x,y));
// Print the output
             cout << "The input values were " << x.dblVal << " and "
                  << y.dblVal << ".\n";
             cout << "The output of feeding the inputs into the adddoubles method is "
                  << out1.dblVal << ".\n";
// Uninitialize COM
             CoUninitialize();
```

```
        return 0;
}
```

2 In the MATLAB Command Window, compile the program as follows:

```
mbuild matlab_com_example.cpp
```

When you run the executable, the program displays two numbers and their sum, as returned by the COM object's `adddoubles`.

Adding Events to COM Objects

MATLAB Builder for .NET supports events, or callbacks, through a MATLAB language pragma. A *pragma* is a directive to .NET Builder, beyond what is conveyed in the MATLAB language itself. The pragma for adding events is `#event`.

MATLAB interprets the `%#event` statement as a comment. But when .NET Builder encapsulates a function, the `#event` pragma tells .NET Builder that the function requires an *outgoing interface* and an *event handler*.

Note The `#event` pragma is supported only for COM components. You can not use this feature with .NET components created by MATLAB Builder for .NET.

To use the `#event` pragma:

1. Write the code for a MATLAB function stub that serves as the prototype for the event. This function stub is the *event function*.
2. Build the COM component as usual. Make sure that you specify the event function you wrote in MATLAB as a method in the component class.
3. In your application, add the code to implement the event handler (the event handler belongs to the COM object created by .NET Builder). The code for the event handler should implement the event function, or function stub, that you wrote in MATLAB.

When an encapsulated M-function (now a method in a COM object in your application) calls the event function, the call is dispatched to the event handler in the application.

Some examples of how you might use callbacks in your code are

- To give the application periodic feedback during a long-running calculation by an encapsulated M-function. For example, if you have a task that requires `n` iterations, you might signal an event to increment a progress bar in the user interface on each iteration.

- To signal a warning during a calculation but continue execution of the task.
- To return intermediate results of a calculation to the user and continue execution of the task.

Using a Callback with a Visual Basic Event

The example in this topic shows how to use a callback in conjunction with a Visual Basic `ProgressBar` control.

The MATLAB function `iterate` runs through `n` iterations and fires an event every `inc` iterations. When the function finishes, it returns a single output. To simulate actually doing something, the sample code includes a `pause` statement in the main loop so that the function waits for 1 second in each iteration.

The sample includes MATLAB functions `iterate.m` and `progress.m`.

iterate.m

```
function [x] = iterate(n,inc)
    %initialize x
    x = 0;
    % Run n iterations, callback every inc time
    k = 0;
    for i=1:n
        k = k + 1;
        if k == inc
            progress(i);
            k = 0;
        end;
        % Do some work on x...
        x = x + 1;
        % Pause for 1 second to simulate doing
        % something
        pause(1);
    end;
```

progess.m

```
function progress(i)
```

```
%#event
i
```

The `iterate` function runs through `n` iterations and calls the `progress` function every `inc` iterations, passing the current iteration number as an argument. When this function is executed in MATLAB, the value of `i` appears each time the `progress` function gets called.

Suppose you create a .NET Builder component that has these two functions included as class methods. For this example the component has a single class named `myclass`. The resulting COM class has a method `iterate` and an event `progress`.

To receive the event calls, implement a "listener" in the application. The Visual Basic syntax for the event handler for this example is

```
Sub aClass_progress(ByVal i As Variant)
```

where `aClass` is the variable name used for your class instance. The `ByVal` qualifier is used on all input parameters of an event function. To enable the listening process, dimension the `aClass` variable with the `WithEvents` keyword.

This example uses a simple Visual Basic form with three `TextBox` controls, one `CommandButton` control, and one `ProgressBar` control. The first text box, `Text1`, inputs the number of iterations, stored in the form variable `N`. The second text box, `Text2`, inputs the callback increment, stored in the variable `Inc`. The third text box, `Text3`, displays the output of the function when it finishes executing. The command button, `Command1`, executes the `iterate` method on your class when pressed. The progress bar control, `ProgressBar1`, updates itself in response to the progress event.

```
'Form Variables
Private WithEvents aClass As myclass    'Class instance
Private N As Long                       'Number of iterations
Private Inc As Long                     'Callback increment
Private Sub Form_Load()
'When form is loaded, create new myclass instance
    Set aClass = New myclass
    'Initialize variables
```

```
    N = 2
    Inc = 1
End Sub
Private Sub Text1_Change()
'Update value of N from Text1 text whenever it changes
    On Error Resume Next
    N = CLng(Text1.Text)
    If Err <> 0 Then N = 2
    If N < 2 Then N = 2
End Sub
Private Sub Text2_Change()
'Update value of Inc from Text2 text whenever it changes
    On Error Resume Next
    Inc = CLng(Text2.Text)
    If Err <> 0 Then Inc = 1
    If Inc <= 0 Then Inc = 1
End Sub
Private Sub Command1_Click()
'Execute function whenever Execute button is clicked
    Dim x As Variant
    On Error GoTo Handle_Error
    'Initialize ProgressBar
    ProgressBar1.Min = 1
    ProgressBar1.Max = N
    Text3.Text = ""
    'Iterate N times and call back at Inc intervals
    Call aClass.iterate(1, x, CDbl(N), CDbl(Inc))
    Text3.Text = Format(x)
    Exit Sub
Handle_Error:
    MsgBox (Err.Description)
End Sub
Private Sub aClass_progress(ByVal i As Variant)
'Event handler. Called each time the iterate function
'calls the progress function. Progress bar is updated
'with the value passed in, causing the control to advance.
    ProgressBar1.Value = i
End Sub
```

Passing Arguments

When it encapsulates MATLAB functions, MATLAB Builder for .NET adds the MATLAB function arguments to the argument list of the class methods it creates. Thus, if a MATLAB function uses varargin and/or varargout, .NET Builder adds these arguments to the argument list of the class method. They are added at the end of the argument list for input and output arguments.

You can pass multiple arguments as a varargin array by creating a Variant array, assigning each element of the array to the respective input argument.

See "Producing a COM Class" on page 12-22 for more information about mapping of input and output arguments.

Creating and Using a varargin Array in Visual Basic Programs

The following example creates a varargin array to call a method encapsulating a MATLAB function of the form y = foo(varargin).

The MWUtil class included in the MWComUtil utility library provides the MWPack helper function to create varargin parameters.

```
Function foo(x1 As Variant, x2 As Variant, x3 As Varaint, _
             x4 As Variant, x5 As Variant) As Variant
   Dim aClass As Object
   Dim v(1 To 5) As Variant
   Dim y As Variant

   On Error Goto Handle_Error
   v(1) = x1
   v(2) = x2
   v(3) = x3
   v(4) = x4
   v(5) = x5
   aClass = CreateObject("mycomponent.myclass.1_0")
   Call aClass.foo(1,y,v)
   foo = y
   Exit Function
Handle_Error:
```

```
      foo = Err.Description
   End Function
```

Creating and Using varargout in Visual Basic Programs

The next example processes a `varargout` argument as three separate arguments. This function uses the `MWUnpack` function in the utility library.

The MATLAB function used is `varargout = foo(x1,x2)`.

```
Sub foo(Xout1 As Variant, Xout2 As Variant, Xout3 As Variant, _
        Xin1 As Variant, Xin2 As Variant)
   Dim aClass As Object
   Dim aUtil As Object
   Dim v As Variant

   On Error Goto Handle_Error
   aUtil = CreateObject("MWComUtil.MWUtil")
   aClass = CreateObject("mycomponent.myclass.1_0")
   Call aClass.foo(3,v,Xin1,Xin2)
   Call aUtil.MWUnpack(v,0,True,Xout1,Xout2,Xout3)
   Exit Sub
Handle_Error:
   MsgBox(Err.Description)
End Sub
```

Using Flags to Control Array Formatting and Data Conversion

Generally, you should write your application code so that it matches the arguments (input and output) of the MATLAB functions that are encapsulated in the COM objects that you are using. The mapping of arguments from MATLAB to Visual Basic is fully described in MATLAB to COM VARIANT Conversion Rules on page 12-11 and COM VARIANT to MATLAB Conversion Rules on page 12-15.

In some cases it is not possible to match the two kinds of arguments exactly; for example, when existing MATLAB code is used in conjunction with a third party product such as Microsoft Excel. For these and other cases, .NET Builder supports formatting and conversion flags that control how array data is formatted in both directions (input and output).

Overview

When it creates a component, .NET Builder includes a component property named `MWFlags`. The `MWFlags` property is readable and writable.

The `MWFlags` property consists of two sets of constants: *array formatting flags* and *data conversion flags*. Array formatting flags affect the transformation of arrays, whereas data conversion flags deal with type conversions of individual array elements.

Array Formatting Flags

The following tables provide a quick overview of how to use array formatting flags to specify conversions for input and output arguments.

<table>
<tr><th>Name of Flag</th><th>Possible Values of Flag</th><th>Results of Conversion</th></tr>
<tr><td rowspan="3">InputArrayFormat</td><td>mwArrayFormatMatrix (default)</td><td>MATLAB matrix from general Variant data.</td></tr>
<tr><td>mwArrayFormatCell</td><td>MATLAB cell array from general Variant data.</td></tr>
<tr><td colspan="2">Array data from an Excel range is coded in Visual Basic as an array of Variant. Since MATLAB functions typically have matrix arguments, using the default setting makes sense when you are dealing with data from Excel.</td></tr>
<tr><td rowspan="8">OutputArrayFormat</td><td>mwArrayFormatAsIs</td><td>Array of Variant</td></tr>
<tr><td colspan="2">Converts arrays according to the default conversion rules listed in MATLAB to COM VARIANT Conversion Rules on page 12-11.</td></tr>
<tr><td>mwArrayFormatMatrix</td><td>A Variant containing an array of a basic type.</td></tr>
<tr><td>mwArrayFormatCell</td><td>MATLAB cell array from general Variant data.</td></tr>
<tr><td>AutoResizeOutput</td><td>When this flag is set, the target range automatically resizes to fit the resulting array. If this flag is not set, the target range must be at least as large as the output array or the data is truncated.</td></tr>
<tr><td colspan="2">Use this flag for Excel Range objects passed directly as output parameters.</td></tr>
<tr><td>TransposeOutput</td><td>Transposes all array output.</td></tr>
<tr><td colspan="2">Use this flag when dealing with an encapsulated M-function whose output is a one-dimensional array. By default, MATLAB handles one-dimensional arrays as 1-by-n matrices (that is, as row vectors). Change this default with the TransposeOutput flag if you prefer column output.</td></tr>
</table>

Using Array Formatting Flags

To use the following example, make sure that you reference the `MWComUtil` library in the current project:

1 Click **Tools > References**.

2 Click **MWComUtil 7.5 Type Library**.

Consider the following Visual Basic function definition for `foo`.

```
Sub foo( )
   Dim aClass As mycomponent.myclass
   Dim var1(1 To 2, 1 To 2), var2 As Variant
   Dim x(1 To 2, 1 To 2) As Double
   Dim y1,y2 As Variant

   On Error Goto Handle_Error
   var1(1,1) = 11#
   var1(1,2) = 12#
   var1(2,1) = 21#
   var1(2,2) = 22#
   x(1,1) = 11
   x(1,2) = 12
   x(2,1) = 21
   x(2,2) = 22
   var2 = x
   Set aClass = New mycomponent.myclass
   Call aClass.foo(1,y1,var1)
   Call aClass.foo(1,y2,var2)
   Exit Sub
Handle_Error:
   MsgBox(Err.Description)
End Sub
```

The example has two `Variant` variables, `var1` and `var2`. These two variables contain the same numerical data, but internally they are structured differently; one is a 2-by-2 array of `variant` and the other is a 1-by-1 array of `variant`. The variables are described in the following table:

	var1	var2
Numerical data	11 12 21 22	11 12 21 22
Internal structure in Visual Basic	2-by-2 array of `Variant`. Each `variant` is a 1-by-1 array of `Double`.	1-by-1 `Variant`, which contains a 2-by-2 array of `Double`
Result of conversion by .NET Builder according to the default data conversion rules	2-by-2 cell array. Each element is a 1-by-1 array of `double`.	2-by-2 matrix. Each element is a `Double`.

The `InputArrayFormat` flag controls how the arrays are handled. In this example, the value for the `InputArrayFormat` flag is the default, which is `mwArrayFormatMatrix`. The default causes an array to be converted to a matrix. See the table for the result of the conversion of `var2`.

To specify a cell array (instead of a matrix) as input to the function call, set the `InputArrayFormat` flag to `mwArrayFormatCell` instead of the default. Do this in this example by adding the following line after creating the class and before the method call:

```
aClass .MWFlags.ArrayFormatFlags.InputArrayFormat =
mwArrayFormatCell
```

Setting the flag to `mwArrayFormatCell` causes all array input to the encapsulated M-function to be converted to cell arrays.

Modifying Output Format. Similarly, you can manipulate the format of output arguments using the `OutputArrayFormat` flag. You can also modify array output with the `AutoResizeOutput` and `TransposeOutput` flags.

Output Format in VBScript. When calling a COM object in VBScript you need to make sure that you set `MWFlags` for the COM object to specify cell array for the output. Also, you must use an enumeration (the enumeration value for a cell array is 2) to make the specification (rather than specifying `mwArrayFormatCell`).

The following sample code shows how to accomplish this:

```
obj.MWFlags.ArrayFormatFlags.OutputArrayFormat = 2
```

Using Data Conversion Flags

Two data conversion flags, `CoerceNumericToType` and `InputDateFormat`, govern how numeric and date types are converted from Visual Basic to MATLAB.

To use the following example, make sure that you reference the `MWComUtil` library in the current project:

1. Click **Tools > References**.

2. Click **MWComUtil 7.5 Type Library**.

This example converts `var1` of type `Variant/Integer` to an `int16` and `var2` of type `Variant/Double` to a `double`.

```
Sub foo( )
   Dim aClass As mycomponent.myclass
   Dim var1, var2 As Variant
   Dim y As Variant

   On Error Goto Handle_Error
   var1 = 1
   var2 = 2#
   Set aClass = New mycomponent.myclass
   Call aClass.foo(1,y,var1,var2)
   Exit Sub
Handle_Error:
   MsgBox(Err.Description)
End Sub
```

If the original MATLAB function expects `doubles` for both arguments, this code might cause an error. One solution is to assign a `double` to `var1`, but this may not be possible or desirable. As an alternative, you can set the `CoerceNumericToType` flag to `mwTypeDouble`, causing the data converter to convert all numeric input to `double`. To do this, place the following line after creating the class and before calling the methods:

```
aClass .MWFlags.DataConversionFlags.CoerceNumericToType =
mwTypeDouble
```

The next example shows how to use the `InputDateFormat` flag, which controls how the Visual Basic `Date` type is converted. The example sends the current date and time as an input argument and converts it to a string.

```
Sub foo( )
   Dim aClass As mycomponent.myclass
   Dim today As Date
   Dim y As Variant

   On Error Goto Handle_Error
   today = Now
   Set aClass = New mycomponent.myclass
   aClass. MWFlags.DataConversionFlags.InputDateFormat =
mwDateFormatString
   Call aClass.foo(1,y,today)
   Exit Sub
Handle_Error:
   MsgBox(Err.Description)
End Sub
```

The next example uses an `MWArg` object to modify the conversion flags for one argument in a method call. In this case the first output argument (y1) is coerced to a `Date`, and the second output argument (y2) uses the current default conversion flags supplied by `aClass`.

```
Sub foo(y1 As Variant, y2 As Variant)
    Dim aClass As mycomponent.myclass
    Dim ytemp As MWArg
 Dim today As Date

 On Error Goto Handle_Error
 today = Now
 Set aClass = New mycomponent.myclass
 Set ytemp = New MWArg
 ytemp.MWFlags.DataConversionFlags.OutputAsDate = True
 Call aClass.foo(2, ytemp, y2, today)
 y1 = ytemp
```

```
 Exit Sub
Handle_Error:
 MsgBox(Err.Description)
End Sub
```

Special Flags for Some Visual Basic Types

In general, you use the `MWFlags` class property to change specified behaviors of the conversion from Visual Basic `Variant` types to MATLAB types, and vice versa. There are some exceptions — some types generated by .NET Builder have their own `MWFlags` property. When you use these particular types, the method call behaves according to the settings of the type and not of the class containing the method being called. The exceptions are for the following types generated by .NET Builder:

- `MWStruct`
- `MWField`
- `MWComplex`
- `MWSparse`
- `MWArg`

Note The `MWArg` class is supplied specifically for the case when a particular argument needs different settings from the default class properties.

Using MATLAB Global Variables

Global variables are variables that are declared in MATLAB with the `global` keyword. .NET Builder automatically converts all global variables shared by the M-files that make up a class to properties on that class. Class properties allow an object to retain an internal state between method calls.

Properties are particularly useful when you have a large array containing values that do not change often, but you need to operate on it frequently. In this case, you can set the array once as a class property and operate on it repeatedly without incurring the overhead of passing (and converting) the data for passing to each method every time it is called.

Using MATLAB Global Variables in Visual Basic

The following example shows how to use a class property in a matrix factorization class. The example develops a class that performs Cholesky, LU, and QR factorizations on the same matrix. It stores the input matrix (coded as `A` in MATLAB) as a class property so that it does not need to be passed to the factorization routines.

Consider these three M-files.

`Cholesky.m`

```
function [L] = Cholesky()
    global A;
    if (isempty(A))
        L = [];
        return;
    end
    L = chol(A);
```

`LUDecomp.m`

```
function [L,U] = LUDecomp()
    global A;
    if (isempty(A))
        L = [];
        U = [];
```

```
        return;
    end
    [L,U] = lu(A);
```

QRDecomp.m

```
function [Q,R] = QRDecomp()
    global A;
    if (isempty(A))
        Q = [];
        R = [];
        return;
    end
    [Q,R] = qr(A);
```

These three files share a common global variable A. Each function performs a matrix factorization on A and returns the results.

To build the class:

1. Create a new .NET Builder project named mymatrix with a version of 1.0.

2. Add a single class called myfactor to the component.

3. Add the above three M-files to the class.

4. Build the component.

To test your application, make sure that you reference the library generated by .NET Builder in the current Visual Basic project:

1. Click **Project > References** in the Visual Basic main menu.

2. Click **mymatrix 1.0 Type Library**.

Use the following Visual Basic subroutine to test the myfactor class.

Sub TestFactor

```
Sub TestFactor()
    Dim x(1 To 2, 1 To 2) As Double
```

```
    Dim C As Variant, L As Variant, U As Variant, _
    Q As Variant, R As Variant
    Dim factor As myfactor

    On Error GoTo Handle_Error
    Set factor = New myfactor
    x(1, 1) = 2#
    x(1, 2) = -1#
    x(2, 1) = -1#
    x(2, 2) = 2#
    factor.A = x
    Call factor.cholesky(1, C)
    Call factor.ludecomp(2, L, U)
    Call factor.qrdecomp(2, Q, R)
    Exit Sub
Handle_Error:
    MsgBox (Err.Description)
End Sub
```

Run the subroutine, which does the following:

1. Creates an instance of the `myfactor` class
2. Assigns a double matrix to the property `A`
3. Calls the three factorization methods

Blocking Execution of a Console Application that Creates Figures

MATLAB Builder for .NET adds a special `MCRWaitForFigures` method to each class in the COM components that it creates. `MCRWaitForFigures` takes no arguments. Your application can call `MCRWaitForFigures` any time during execution.

The purpose of `MCRWaitForFigures` is to block execution of a calling program as long as figures created in encapsulated M-code are displayed. Typically you use `MCRWaitForFigures` when

- There are one or more figures open that were created by an instance of a COM object created by .NET Builder.
- 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 `MCRWaitForFigures` is called, execution of the calling program is blocked if any figures created by the calling object remain open.

Note Be careful when calling the `MCRWaitForFigures` method. Calling this method from a Visual Basic UI or from an interactive program like Excel can hang the application. This method should be called *only* from console-based programs.

Using MCRWaitForFigures to Block Execution

The following example illustrates using `MCRWaitForFigures` from a C++ console application. The example uses a COM object created by .NET Builder; the object encapsulates M-code that draws a simple plot.

1. Create a work directory for your source code. In this example, the directory is `D:\work\plotdemo`.

2. Create the following m-file in this directory:

```
drawplot.m

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

3 Use .NET Builder to create a COM component with the following properties:

Component name	plotdemo
Class name	plotdemoclass
Version	1.0

Note Instead of using the Deployment Tool, you can create the component by issuing the following command at the MATLAB prompt:

```
mcc -d 'D:\work\plotdemo\src' -v -B
   'ccom:plotdemo,plotdemoclass,1.0' 'D:\Work\plotdemo\drawplot.m'
```

---

4 Create a C++ program in a file named `runplot.cpp` with the following code:

```
// Include the following files generated by
// MATLAB Builder for .NET:
#include "src\plotdemo_idl.h"
#include "src\plotdemo_idl_i.c"

int main()
{
    // Initialize the COM library
    HRESULT hr = CoInitialize(NULL);
    // Create an instance of the COM object you created
    Iplotdemoclass* pIplotdemoclass = NULL;
    hr = CoCreateInstance(CLSID_plotdemoclass, NULL, _
         CLSCTX_INPROC_SERVER, IID_Iplotdemoclass, _
         (void **)&pIplotdemoclass);
    // Call the drawplot method
    hr = pIplotdemoclass->drawplot();
    // Block execution until user dismisses the figure window
```

```
        hr = pIplotdemoclass->MCRWaitForFigures();
        // Uninitialize COM
        CoUninitialize();
        return 0;
    }
```

5 In the MATLAB Command Window, build the application as follows:

```
mbuild runplot.cpp
```

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 `MCRWaitForFigures`. 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.

Obtaining Registry Information

When programming with COM components, you might need details about a component. You can use componentinfo, which is a MATLAB function, to query the system registry for details about any installed MATLAB Builder for .NET component.

This example queries the registry for a component named mycomponent and a version of 1.0. This component has four methods: mysum, randvectors, getdates, and myprimes; two properties: m and n; and one event: myevent.

```
Info = componentinfo('mycomponent', 1, 0)

Info =

       Name: 'mycomponent'
      TypeLib: 'mycomponent 1.0 Type Library'
        LIBID: '{3A14AB34-44BE-11D5-B155-00D0B7BA7544}'
    MajorRev: 1
    MinorRev: 0
    FileName: 'D:\Work\ mycomponent\distrib\mycomponent_1_0.dll'
    Interfaces: [1x1 struct]
    CoClasses: [1x1 struct]

Info.Interfaces

ans =

      Name: 'Imyclass'
       IID: '{3A14AB36-44BE-11D5-B155-00D0B7BA7544}'

Info.CoClasses

ans =

          Name: 'myclass'
         CLSID: '{3A14AB35-44BE-11D5-B155-00D0B7BA7544}'
         ProgID: 'mycomponent.myclass.1_0'
   VerIndProgID: 'mycomponent.myclass'
InprocServer32:'D:\Work\mycomponent\distrib\mycomponent_1_0.dll'
```

```
        Methods: [1x4 struct]
     Properties: {'m', 'n'}
         Events: [1x1 struct]

Info.CoClasses.Events.M

ans =

function myevent(x, y)

Info.CoClasses.Methods

ans =

1x4 struct array with fields:
    IDL
    M
    C
    VB

Info.CoClasses.Methods.M

ans =

function [y] = mysum(varargin)

ans =

function [varargout] = randvectors()

ans =

function [x] = getdates(n, inc)

ans =

function [p] = myprimes(n)
```

The returned structure contains fields corresponding to the most important information from the registry and type library for the component.

Handling Errors During a Method Call

If your application generates an error while creating a class instance or during a class method call, the current procedure creates an exception.

Visual Basic provides an exception handling capability through the `On Error Goto <label>` statement, in which the program execution jumps to `<label>` when an error occurs. (`<label>` must be located in the same procedure as the `On Error Goto` statement.) All errors in Visual Basic are handled this way, including errors within the MATLAB code that you have encapsulated into a COM object. An exception creates a Visual Basic `ErrObject` object in the current context in a variable called `Err`.

See the Visual Basic documentation for a detailed discussion on Visual Basic error handling.

Using COM Components in Visual Basic Applications

Magic Square Example (p. 11-2)	Demonstrates the creation of a COM component from a simple MATLAB M-file
Creating an Excel Add-In: Spectral Analysis Example (p. 11-9)	Shows the creation of a comprehensive Excel add-in
Univariate Interpolation (p. 11-23)	Uses Akima's Univariate Interpolation example available on the MathWorks Web site
Matrix Calculator (p. 11-31)	Creates a matrix calculator and shows how to compile the MATLAB functions into a COM component
Curve Fitting (p. 11-42)	Demonstrates the optimal fitting of a nonlinear function to a set of data
Bouncing Ball Simulation (p. 11-50)	An adaptation of the `ballode` demo provided with core MATLAB

Magic Square Example

This example uses a simple M-file that takes a single input and creates a magic square of that size. It then builds a COM component using this M-file as a class method. Finally, the example shows the integration of this component into a stand-alone Visual Basic application. The application accepts the magic square size as input and displays the matrix in a ListView control box.

Note ListView is a Windows Form control that displays a list of items with icons. You can use a list view to create a user interface like the right pane of Windows Explorer. See the MSDN Library for more information about Windows Form controls.

Creating the M-File

To get started, create the M-file `mymagic.m` containing the following code:

```
function y = mymagic(x)
y = magic(x);
```

Using the Deployment Tool to Create and Build the Project

1. If you have not already done so, execute the following command in MATLAB:

   ```
   mbuild -setup
   ```

   Be sure to choose a supported compiler. See "Compiler Requirements" on page 7-2.

2. Specify a COM component as follows:

   a. While in MATLAB, issue the following command to open Deployment Tool:

      ```
      deploytool
      ```

   b. Create a project with the following settings:

Setting	Value
Project name	`magicdemo`
Class name	`magicdemoclass`
Project directory	The name of your work directory followed by the component name. In this example, that is `D:\Work\MagicSquareExample\magicdemo`.
Show verbose output	Selected

c. Locate your work directory and navigate to the `MagicDemoComp` directory, which contains the M-file for the `makesquare` function. Add the `makesquare.m` file to the project.

3 Build the component by clicking the Build icon in the Deployment Tool toolbar.

The build process begins, and a log of the build appears in the Output pane of the Deployment Tool dialog box. The files that are needed for the component are copied to two newly created directories, `src` and `distrib`, in the `magicdemo` directory. A copy of the build log is placed in the `src` directory.

Creating the Visual Basic Project

Note This procedure assumes that you are using Visual Basic 6.0.

1 Start Visual Basic.

2 In the New Project dialog box, select **Standard EXE** as the project type and click **Open**. This creates a new Visual Basic project with a blank form.

3 From the main menu, click **Project > References** to open the Project References dialog box.

4 Select **magicdemo 1.0 Type Library** from the list of available components and click **OK**.

5 Returning to the Visual Basic main menu, click **Project > Components** to open the Components dialog box.

6 Select **Microsoft Windows Common Controls 6.0** and click **OK**. You will use the `ListView` control from this component library.

Creating the User Interface

After you create the project, add a series of controls to the blank form to create a form with the following settings:

Control Type	Control Name	Properties	Purpose
`Frame`	`Frame1`	Caption = `Magic Squares Demo`	Groups controls
`Label`	`Label1`	Caption = `Magic Square Size`	Labels the magic square edit box.
`TextBox`	`edtSize`		Accepts input of magic square size.
`CommandButton`	`btnCreate`	Caption = `Create`	When pressed, creates a new magic square with current size.
`ListView`	`lstMagic`	GridLines = `True` LabelEdit = `lvwManual` View = `lvwReport`	Displays the magic square.

When the form and controls are complete, add the following code to the form. This code references the control and variable names listed above. If you have given different names for any of the controls or any variable, change this code to reflect those differences.

```
Private Size As Double 'Holds current matrix size
Private theMagic As magicdemo.magicdemoclass 'magic object instance

Private Sub Form_Load()
'This function is called when the form is loaded.
'Creates a new magic class instance.
    On Error GoTo Handle_Error
```

```
    Set theMagic = New magicdemo.magicdemoclass
    Size = 0
Exit Sub
Handle_Error:
    MsgBox (Err.Description)
End Sub

Private Sub btnCreate_Click()
'This function is called when the Create button is pressed.
'Calls the mymagic method, and displays the magic square.
    Dim y As Variant
    If Size <= 0 Or theMagic Is Nothing Then Exit Sub
    On Error GoTo Handle_Error
    Call theMagic.mymagic(1, y, Size)
    Call ShowMatrix(y)
    Exit Sub
Handle_Error:
    MsgBox (Err.Description)
End Sub

Private Sub edtSize_Change()
'This function is called when ever the contents of the
'Text box change. Sets the current value of Size.
    On Error Resume Next
    Size = CDbl(edtSize.Text)
    If Err <> 0 Then
        Size = 0
    End If
End Sub

Private Sub ShowMatrix(y As Variant)
'This function populates the ListView with the contents of
'y. y is assumed to contain a 2D array.
    Dim n As Long
    Dim i As Long
    Dim j As Long
    Dim nLen As Long
    Dim Item As ListItem

    On Error GoTo Handle_Error
```

```
    'Get array size
    If IsArray(y) Then
        n = UBound(y, 1)
    Else
        n = 1
    End If
    'Set up Column headers
    nLen = lstMagic.Width / 5
    Call lstMagic.ListItems.Clear
    Call lstMagic.ColumnHeaders.Clear
    Call lstMagic.ColumnHeaders.Add(, , "", nLen, lvwColumnLeft)
    For i = 1 To n
        Call lstMagic.ColumnHeaders.Add(, , _
        "Column " & Format(i), nLen, lvwColumnLeft)
    Next
    'Add array contents
    If IsArray(y) Then
        For i = 1 To n
            Set Item = lstMagic.ListItems.Add(, , "Row " & Format(i))
            For j = 1 To n
                Call Item.ListSubItems.Add(, , Format(y(i, j)))
            Next
        Next
    Else
        Set Item = lstMagic.ListItems.Add(, , "Row 1")
        Call Item.ListSubItems.Add(, , Format(y))
    End If
    Exit Sub
Handle_Error:
    MsgBox (Err.Description)
End Sub
```

Creating the Executable in Visual Basic

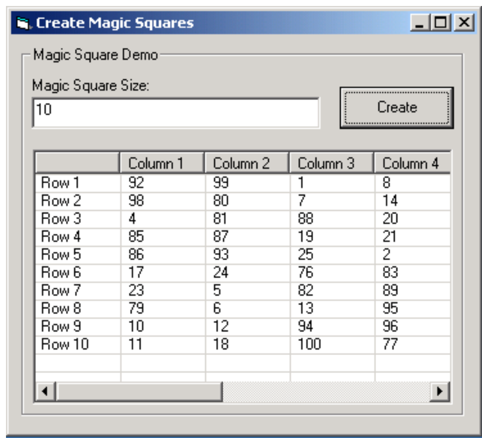
After the code is complete, create the stand-alone executable `magic.exe`:

1 Reopen the project by clicking **File > Save Project** from the main menu. Accept the default name for the main form and enter `magic.vbp` for the project name.

2 Return to the **File** menu. Click **File > Make magic.exe** to create the finished product.

Testing the Application

You can run the `magic.exe` executable as you would any other program. When the main dialog box opens, enter a positive number in the input box and click **Create**. A magic square of the input size appears as shown:



The `ListView` control automatically implements scrolling if the magic square is larger than 4-by-4.

Packaging the Component

As a final step, package the `magicdemo` component and all supporting libraries into a self-extracting executable. Then anyone can install the package on another computer, in particular a computer without MATLAB installed, and use the `magicdemo` application.

To package the component, follow these steps:

1 Return to the Deployment Tool dialog box and open the `magicdemo` project. If necessary, type `deploytool` in the Command Window.

2 Click the Package button in the toolbar.

Deployment Tool creates the `magicdemo_pkg.exe` self-extracting executable.

To install the component onto another computer, copy the `magicdemo_pkg.exe` package to that machine, run `magicdemo_pkg.exe` from a command prompt, and follow the instructions.

Creating an Excel Add-In: Spectral Analysis Example

This example shows how to create a comprehensive Excel add-in to perform spectral analysis. It requires knowledge of Visual Basic forms and controls, as well as Excel workbook events. See the Visual Basic documentation included with Microsoft Excel for a complete discussion of these topics.

The example creates an Excel add-in that performs a fast Fourier transform (FFT) on an input data set located in a designated worksheet range. The function returns the FFT results, an array of frequency points, and the power spectral density of the input data. It places these results into ranges you indicate in the current worksheet. You can also optionally plot the power spectral density.

You develop the function so that you can invoke it from the Excel **Tools** menu and can select input and output ranges through a graphical user interface (GUI).

Creating this add-in requires the following tasks:

- “Building the Component” on page 11-9
- “Integrating the Component with VBA” on page 11-11
- “Creating the Visual Basic Form” on page 11-13
- “Adding the Spectral Analysis Menu Item to Excel” on page 11-18
- “Saving the Add-In” on page 11-19
- “Testing The Add-in” on page 11-20
- “Packaging and Distributing the Add-In” on page 11-22

Building the Component

Your component will have one class with the following two methods:

- The `computefft` method computes the FFT and power spectral density of the input data and computes a vector of frequency points based on the length of the data entered and the sampling interval.

- The plotfft method performs the same operations as computefft, but also plots the input data and the power spectral density in a MATLAB Figure window.

The MATLAB code for these two methods resides in two M-files, computefft.m and plotfft.m, as shown:

```
computefft.m:
function [fftdata, freq, powerspect] = computefft(data, interval)
    if (isempty(data))
        fftdata = [];
        freq = [];
        powerspect = [];
        return;
    end
    if (interval <= 0)
        error('Sampling interval must be greater then zero');
        return;
    end
    fftdata = fft(data);
    freq = (0:length(fftdata)-1)/(length(fftdata)*interval);
    powerspect = abs(fftdata)/(sqrt(length(fftdata)));


plotfft.m:

function [fftdata, freq, powerspect] = plotfft(data, interval)
    [fftdata, freq, powerspect] = computefft(data, interval);
    len = length(fftdata);
    if (len <= 0)
        return;
    end
    t = 0:interval:(len-1)*interval;
    subplot(2,1,1), plot(t, data)
    xlabel('Time'), grid on
    title('Time domain signal')
    subplot(2,1,2), plot(freq(1:len/2), powerspect(1:len/2))
    xlabel('Frequency (Hz)'), grid on
    title('Power spectral density')
```

To build the component, follow these steps:

1. If you have not already done so, execute the following command in MATLAB:

   ```
   mbuild -setup
   ```

   Be sure to choose a supported compiler. See "Compiler Requirements" on page 7-2.

2. Start `deploytool`.

3. Create a new project with these settings:

   - **Project name**: `Fourier`
   - **Class name**: `Fourier`

4. Add the `computefft.m` and `plotfft.m` M-files to the project.

5. Save the project.

6. Click the Build icon in the toolbar to create the component.

Integrating the Component with VBA

The next task is to implement the necessary VBA code to integrate the component into Excel.

Follow these steps to open Excel and select the libraries you need to develop the add-in:

1. Start Excel.

2. From the Excel main menu, click **Tools > Macro > Visual Basic Editor** to open the Visual Basic Editor.

3. Click **Tools > References** to display the Project References dialog box.

4. Select **Fourier 1.0 Type Library** and **MWComUtil 7.5 Type Library**.

Creating the Main VBA Code Module

The add-in requires some initialization code and some global variables to hold the application's state between function invocations. To achieve this, implement a Visual Basic code module to manage these tasks, as follows:

1 Right-click **VBAProject** in the Project window and click **Insert > Module**.

   A new module appears under **Modules** in the **VBA Project**.

2 In the module's property page, set the **Name** property to **FourierMain**.

3 Enter the following code in the **FourierMain** module:

```
' FourierMain - Main module stores global state of controls
' and provides initialization code
'
'Global instance of Fourier object
Public theFourier As Fourier.Fourier
'Global instance of MWComplex to accept FFT
Public theFFTData As MWComplex
'Input data range
Public InputData As Range
'Sampling interval
Public Interval As Double
'Output frequency data range
Public Frequency As Range
'Output power spectral density range
Public PowerSpect As Range
'Holds the state of plot flag
Public bPlot As Boolean
'Global instance of MWUtil object
Public theUtil as MWUtil
'Module-is-initialized flag
Public bInitialized As Boolean
Private Sub LoadFourier()
'Initializes globals and Loads the Spectral Analysis form
    Dim MainForm As frmFourier
    On Error GoTo Handle_Error
    Call InitApp
    Set MainForm = New frmFourier
```

```
        Call MainForm.Show
        Exit Sub
    Handle_Error:
        MsgBox (Err.Description)
    End Sub

    Private Sub InitApp()
    'Initializes classes and libraries. Executes once
    'for a given session of Excel
        If bInitialized Then Exit Sub
        On Error GoTo Handle_Error
        If theFourier Is Nothing Then
            Set theFourier = New Fourier.Fourier
        End If
        If theFFTData Is Nothing Then
            Set theFFTData = New MWComplex
        End If
        bInitialized = True
        Exit Sub
    Handle_Error:
        MsgBox (Err.Description)
    End Sub
```

Creating the Visual Basic Form

The next task is to develop a user interface for your add-in using the Visual Basic editor. Follow these steps to create a new user form and populate it with the necessary controls:

1. Right-click **VBAProject** in the Project window and click **Insert > UserForm**.

   A new form appears under **Forms** in the VBA Project.

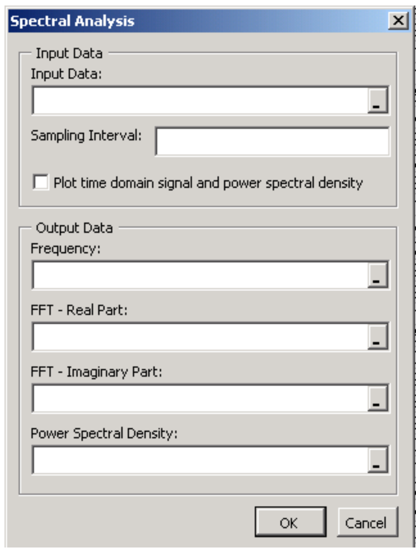
2. In the form's property page, set the **Name** property to `frmFourier` and the **Caption** property to `Spectral Analysis`.

3. Add a series of controls to the blank form to complete the dialog box, as summarized in the following table:

Control Type	Control Name	Properties	Purpose
Frame	Frame1	Caption = Input Data	Groups all input controls.
Label	Label1	Caption = Input Data:	Labels the RefEdit for input data.
RefEdit	refedtInput		Selects range for input data.
Label	Label2	Caption = Sampling Interval	Labels the text box for sampling interval.
TextBox	edtSample		Specifies the sampling interval.
CheckBox	chkPlot	Caption = Plot time domain Signal and Power Spectral Density	Plots input data and power spectral density.
Frame	Frame2	Caption = Output Data	Groups all output controls.
Label	Label3	Caption = Frequency:	Labels the RefEdit for frequency output.
RefEdit	refedtFreq		Selects output range for frequency points.
Label	Label4	Caption = FFT - Real Part:	Labels the RefEdit for real part of FFT.
RefEdit	refedtReal		Selects output range for real part of FFT of input data.
Label	Label5	Caption = FFT - Imaginary Part:	Labels the RefEdit for imaginary part of FFT.
RefEdit	refedtImag		Selects output range for imaginary part of FFT of input data.

Control Type	Control Name	Properties	Purpose
`Label`	`Label6`	Caption = `Power Spectral Density`	Labels the `RefEdit` for power spectral density.
`RefEdit`	`refedtPowSpect`		Selects output range for power spectral density of input data.
`CommandButton`	`btnOK`	Caption = `OK` Default = `True`	Executes the function and dismisses the dialog
`CommandButton`	`btnCancel`	Caption = `Cancel` Cancel = `True`	Dismisses the dialog box without executing the function.

The following figure shows the resulting layout.



4 When the form and controls are complete, right-click anywhere in the form and click **View Code**. The following code listing shows the code to implement. Note that this code references the control and variable names

listed in the previous table. If you have renamed any of the controls or any global variable, change this code to reflect those differences.

```
'
'frmFourier Event handlers
'
Private Sub UserForm_Activate()
'UserForm Activate event handler. This function gets called before
'showing the form, and initializes all controls with values stored
'in global variables.
    On Error GoTo Handle_Error
    If theFourier Is Nothing Or theFFTData Is Nothing Then Exit Sub
    'Initialize controls with current state
    If Not InputData Is Nothing Then
        refedtInput.Text = InputData.Address
    End If
    edtSample.Text = Format(Interval)
    If Not Frequency Is Nothing Then
        refedtFreq.Text = Frequency.Address
    End If
    If Not IsEmpty (theFFTData.Real) Then
    If IsObject(theFFTData.Real) And TypeOf theFFTData.Real Is Range Then
            refedtReal.Text = theFFTData.Real.Address
        End If
    End If
    If Not IsEmpty (theFFTData.Imag) Then
    If IsObject(theFFTData.Imag) And TypeOf theFFTData.Imag Is Range Then
            refedtImag.Text = theFFTData.Imag.Address
        End If
    End If
    If Not PowerSpect Is Nothing Then
        refedtPowSpect.Text = PowerSpect.Address
    End If
    chkPlot.Value = bPlot
    Exit Sub
Handle_Error:
    MsgBox (Err.Description)
End Sub

Private Sub btnCancel_Click()
```

```
'Cancel button click event handler. Exits form without computing fft
'or updating variables.
    Unload Me
End Sub
Private Sub btnOK_Click()
'OK button click event handler. Updates state of all variables from controls
'and executes the computefft or plotfft method.
    Dim R As Range

    If theFourier Is Nothing Or theFFTData Is Nothing Then GoTo Exit_Form
    On Error Resume Next
    'Process inputs
    Set R = Range(refedtInput.Text)
    If Err <> 0 Then
        MsgBox ("Invalid range entered for Input Data")
        Exit Sub
    End If
    Set InputData = R
    Interval = CDbl(edtSample.Text)
    If Err <> 0 Or Interval <= 0 Then
        MsgBox ("Sampling interval must be greater than zero")
        Exit Sub
    End If
    'Process Outputs
    Set R = Range(refedtFreq.Text)
    If Err = 0 Then
        Set Frequency = R
    End If
    Set R = Range(refedtReal.Text)
    If Err = 0 Then
        theFFTData.Real = R
    End If
    Set R = Range(refedtImag.Text)
    If Err = 0 Then
        theFFTData.Imag = R
    End If
    Set R = Range(refedtPowSpect.Text)
    If Err = 0 Then
        Set PowerSpect = R
    End If
```

```
    bPlot = chkPlot.Value
    'Compute the fft and optionally plot power spectral density
    If bPlot Then
        Call theFourier.plotfft(3, theFFTData, Frequency, PowerSpect,_
InputData, Interval)
    Else
        Call theFourier.computefft(3, theFFTData, Frequency, PowerSpect,_
InputData, Interval)
    End If
    GoTo Exit_Form
Handle_Error:
    MsgBox (Err.Description)
Exit_Form:
    Unload Me
End Sub
```

Adding the Spectral Analysis Menu Item to Excel

The last task in the integration process is to add a menu item to Excel so that you can invoke the tool from Excel's **Tools** menu. To do this you add event handlers for the workbook's `AddinInstall` and `AddinUninstall` events; these are events that install and uninstall menu items. The menu item calls the `LoadFourier` function in the `FourierMain` module.

Follow these steps to implement the menu item:

1. Right-click **ThisWorkbook** in the Visual Basic project window and click **View Code**.

2. Add the following code to the **ThisWorkbook** object:

```
Private Sub Workbook_AddinInstall()
'Called when Addin is installed
    Call AddFourierMenuItem
End Sub

Private Sub Workbook_AddinUninstall()
'Called when Addin is uninstalled
    Call RemoveFourierMenuItem
End Sub
```

```
Private Sub AddFourierMenuItem()
    Dim ToolsMenu As CommandBarPopup
    Dim NewMenuItem As CommandBarButton

    'Remove if already exists
    Call RemoveFourierMenuItem
    'Find Tools menu
    Set ToolsMenu = Application.CommandBars(1).FindControl(ID:=30007)
    If ToolsMenu Is Nothing Then Exit Sub
    'Add Spectral Analysis menu item
    Set NewMenuItem = ToolsMenu.Controls.Add(Type:=msoControlButton)
    NewMenuItem.Caption = "Spectral Analysis..."
    NewMenuItem.OnAction = "LoadFourier"
End Sub

Private Sub RemoveFourierMenuItem()
Dim CmdBar As CommandBar
Dim Ctrl As CommandBarControl
On Error Resume Next
'Find tools menu and remove Spectral Analysis menu item
Set CmdBar = Application.CommandBars(1)
Set Ctrl = CmdBar.FindControl(ID:=30007)
Call Ctrl.Controls("Spectral Analysis...").Delete
End Sub
```

Saving the Add-In

Name the add-in `Spectral Analysis` and follow these steps to save it:

1. From the Excel main menu, click **File > Properties**.

   The Workbook Properties dialog box appears.

2. Click the **Summary** tab and enter `Spectral Analysis` as the workbook title.

3. Click **OK** to save the edits.

4. Click **File > Save As** from the Excel main menu.

5. Click **Microsoft Excel Add-In (*.xla)** as the file type.

6. Enter `Fourier.xla` as the file name.
7. Click **Save** to save the add-in.

Testing The Add-in

Before distributing the add-in, test it with a sample problem. Spectral analysis is commonly used to find the frequency components of a signal buried in a noisy time domain signal. In this example you will create a data representation of a signal containing two distinct components and add to it a random component. This data along with the output will be stored in columns of an Excel worksheet, and you will plot the time-domain signal along with the power spectral density.

Follow the steps outlined below to create the test problem:

1. Start a new session of Excel with a blank workbook.
2. Click **Tools > Add-Ins** from the main menu.
3. When the **Add-Ins** dialog box comes up, click **Browse**.
4. Browse to the `Fourier.xla` file and click **OK**.
5. The `Spectral Analysis` add-in appears in the available **Add-Ins** list and is selected.
6. Click **OK** to load the add-in.

This add-in installs a menu item under the Excel **Tools** menu. You can display the Spectral Analysis GUI by clicking **Tools > Spectral Analysis**.

Before invoking the add-in, create some data, in this case a signal with components at 15 and 40 Hz. Sample the signal for 10 seconds at a sampling rate of 0.01 second. Put the time points into column A and the signal points into column B.

Creating the Data

Follow these steps to create the data:

1. Enter `0` for cell A1 in the current worksheet.

2. Click on cell A2 and type the formula `= A1 + 0.01`.

3. Drag the formula in cell A2 down the column to cell A1001.

   This procedure fills the range A1:A1001 with the interval 0 to 10 incremented by 0.01.

4. Click on cell B1 and type the formula `SIN(2*PI()*15*A1) + SIN(2*PI()*40*A1) + RAND()`.

5. Repeat the drag procedure to copy this formula to all cells in the range B1:B1001.

Running the Test

Using the column of data (column B), test the add-in as follows:

1. Click **Tools > Spectral Analysis** from the main menu.

2. Click **Input Data**.

3. Click the B1:B1001 range from the worksheet, or type this address into **Input Data**.

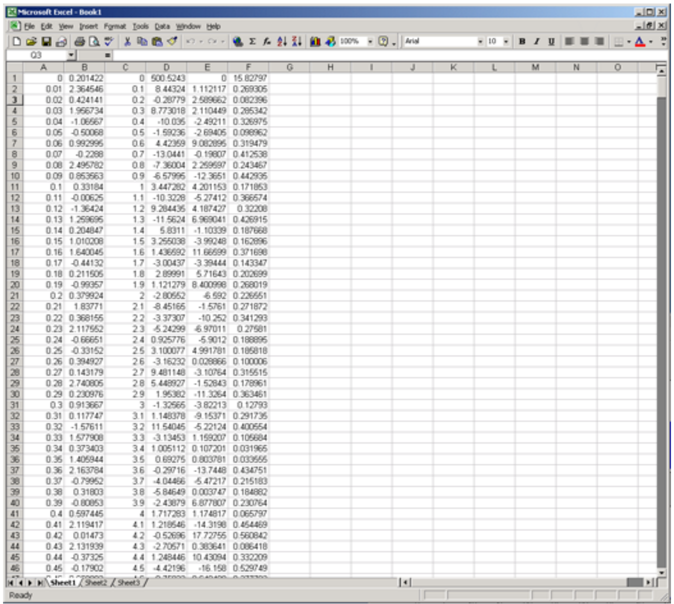
4. Click **Sampling Interval** box and type `0.01`.

5. Click **Plot time domain signal and power spectral density**.

6. Enter `C1:C1001` for frequency output. Similarly, enter `D1:D1001`, `E1:E1001`, and `F1:F1001` for the FFT real and imaginary parts, and spectral density.

7. Click **OK** to run the analysis.

   The following figure shows the output.



The power spectral density reveals the two signals at 15 and 40 Hz.

Packaging and Distributing the Add-In

As a final step, package the add-in, the COM component, and all supporting libraries into a self-extracting executable. This package can be installed onto other computers that need to use the `Spectral Analysis` add-in.

To package and distribute the add-in, follow these steps:

1. Return to the Deployment Tool and open the Fourier project. (If necessary run the `deploytool` command in MATLAB to reopen the Deployment Tool dialog box.)

2. Click the Package button in the toolbar.

   .NET Builder creates the `Fourier_pkg.exe` self-extracting executable.

3. To install this add-in onto another computer, copy the `Fourier_pkg.exe` package to that machine, run it from a command prompt, and follow the instructions.

Univariate Interpolation

This example is created using the Akima's Univariate Interpolation example posted by N. Shyamsundar on the MathWorks Web site. You can download the original M-file from `http://www.mathworks.com/matlabcentral/`. Search for *COM Builder Example: Univariate Interpolation*.

This example shows you how to create the COM component using MATLAB Builder for .NET and how to use this COM component in external Microsoft Visual Basic Code independent of MATLAB. It assumes that you have downloaded the M-file to the *`matlab/work`* directory.

The examples shows how to perform the following tasks:

- "Using the Deployment Tool to Create and Build the Component" on page 11-23
- "Using the Component in Visual Basic" on page 11-24
- "Creating the Visual Basic Form" on page 11-25

Using the Deployment Tool to Create and Build the Component

Build the component as follows:

1. At the MATLAB command prompt, change directories to *`matlab/work`*.

2. If you have not already done so, execute the following command in MATLAB:

   ```
   mbuild -setup
   ```

   Be sure to choose a supported compiler. See "Compiler Requirements" on page 7-2.

3. Open the Deployment Tool dialog box.

   ```
   deploytool
   ```

4. Create a project with the following settings:

Setting	Value
Project name	`UnivariateInterp`.
Class name	`Interp`
Project directory	The name of your work directory followed by the Project name.
Show verbose output	Selected

5. Locate your work directory and navigate to the `UnivariateInterp` directory, and add the M-file to the project.

6. Build the component by clicking the Build button in the Deployment Tool toolbar.

   The build process begins, and a log of the build appears in the Output pane of the Deployment Tool dialog box. The files that are needed for the component are copied to two newly created directories, `src` and `distrib`, in the `UnivariateInterp` directory. A copy of the build log is placed in the `src` directory.

Using the Component in Visual Basic

You can call the component from any application that supports COM.

Follow these steps to create a Visual Basic project and add references to the necessary libraries.

1. Start Visual Basic.

2. Create a new Standard EXE project.

3. Click **Project > References**.

4. Ensure that the following libraries appear:

   `UnivariateInterp 1.0 Type Library`

   `MWComUtil 7.5 Type Library`

Note If you do not see these libraries, you may not have registered the libraries using mwregsvr. Refer to "Component Registration" on page 12-4 for information on this process.

Creating the Visual Basic Form

The next step creates a front end or a Visual Basic form for the application. Your application receives data from the user through this form.

Follow these steps to create a new user form and populate it with the necessary controls.

1 Click **Projects > Component**. Alternatively, press **Ctrl+T**.

   Ensure that **Microsoft Windows Common Controls 6.0** is selected.

   You will use the `ListView` control from this component library.

2 Add a series of controls to the blank form to create an interface using the properties shown in the following table:

Control Type	Control Name	Properties	Purpose
`Form`	`frmInterp`	Caption = `Univariate Interpolation`	Container for all components
`Label`	`lblDataCount`	Caption = `Number of Data Points`	Labels the text box `txtNumDataPts`.
`TextBox`	`txtNumDataPts`	Text =	Number of original data points
`Label`	`lblInterp`	Caption = `Number of Interpolation Points`	Labels the text box `txtInterp`
`TextBox`	`txtInterp`	Text =	Number of points over which to interpolate
`Label`	`lblPlot`	Caption = `Would you like to plot the data?`	Labels the check box `chkPlot`

Control Type	Control Name	Properties	Purpose
CheckBox	chkPlot		When selected, a message is sent to the COM component to plot the data
ListView	lstXData	Name = lstXData GridLines = True LabelEdit = lvwAutomatic View = lvwReport	X-data values. Set the view type to lvwReport to allow the user to add data to the list view
ListView	lstYData	Name = lstYData GridLines = True LabelEdit = lvwAutomatic View = lvwReport	Y-data values. Set the view type to lvwReport to allow the user to add data to the list view
ListView	lstInterp	Name = lstInterp GridLines = True LabelEdit = lvwAutomatic View = lvwReport	Interpolation points
CommandButton	cmdEvaluate	Caption = Evaluate Default = True	Executes the function
CommandButton	cmdCancel	Caption = Cancel Cancel = True	Dismisses dialog box without executing function

3. When the design is complete, save the project by clicking **File > Save**.

4. When prompted for the project name, type `Interp.vbp`, and for the form, type `frmInterp.frm`.

5. To write the underlying code, right-click **frmInterp** in the Project window and click **View Code**.

The following code listing shows the code to implement. Note that this code references the control and variable names listed above. If you have given a different name to any of the controls or any global variable, change this code to reflect the differences.

```
Private theInterp As UnivariateInterp.Interp 'Variable to hold the COM object

Private Sub cmdCancel_Click()
    ' Unload the form if the user hits the cancel button.
    Unload Me
End Sub

Private Sub Form_Initialize()
    On Error GoTo Handle_Error
    ' Create the COM object
    ' If there is an error, handle it accordingly.
    Set theInterp = New UnivariateInterp.Interp
    ' Set the flags such that the input is always passed as double data.
    theInterp.MWFlags.DataConversionFlags.CoerceNumericToType = mwTypeDouble
    Exit Sub
Handle_Error:
    ' Error handling code
    MsgBox ("Error " & Err.Description)
End Sub

Private Sub Form_Load()
    ' Set the run time properties of the components
    Dim Len1 As Long ' Variable to hold length parameter of the list box
    Dim Len2 As Long ' Variable to hold the length parameter of the list box
    Len2 = lstInterp.Width / 2
    Len1 = (lstInterp.Width - Len2) - 150
    ' Add the column headers to the list boxes
    Call lstXData.ColumnHeaders.Add(, , "XData", Len2)
    Call lstYData.ColumnHeaders.Add(, , "YData", Len2)
    Call lstInterp.ColumnHeaders.Add(, , "Interp Data", Len1)
    Call lstInterp.ColumnHeaders.Add(, , "Interp YData", Len2)

    ' Enable the grid lines
    lstXData.GridLines = True
    lstYData.GridLines = True
```

```
    lstInterp.GridLines = True
    lstInterp.FullRowSelect = True

    ' Set the Tab indices for each of the components
    txtNumDataPts.TabIndex = 1
    txtInterp.TabIndex = 2
    lstXData.TabIndex = 3
    lstYData.TabIndex = 4
    lstInterp.TabIndex = 5
    cmdEvaluate.TabIndex = 6
    cmdCancel.TabIndex = 7
End Sub

Private Sub txtInterp_Change()
    ' If user changes number of interpolation points, set the interpolation
    ' point listbox to accomodate the new number of points.
    Dim loopCount As Integer ' loop count
    Dim numData As Integer
    On Error GoTo Handle_Error
    ' First clear the listbox
    Call lstInterp.ListItems.Clear
    ' Create space for the requested number of interpolation points
    If Not (txtInterp.Text = "") Then
        numData = CDbl(txtInterp.Text)
        For loopCount = 1 To numData
            Call lstInterp.ListItems.Add(loopCount, , "")
        Next
    End If
    Exit Sub
Handle_Error:
    ' Reset the list to 0 elements and also the text box to an empty string.
    MsgBox ("Invalid value for number of Data points")
    lstInterp.ListItems.Clear
    txtInterp.Text = ""
End Sub

Private Sub txtNumDataPts_Change()
    ' If the user changes the number of data points, set the XData and YData
    ' listboxes to accomodate the new number of points.
    Dim loopCount As Integer ' loop count
```

```
    Dim numData As Integer
    On Error GoTo Handle_Error
    ' First clear both the listbox (XData and YData)
    Call lstXData.ListItems.Clear
    Call lstYData.ListItems.Clear
    ' Create space for the requested number of data points (XData and YData).
    If Not (txtNumDataPts.Text = "") Then
        numData = CDbl(txtNumDataPts.Text)
        For loopCount = 1 To numData
            Call lstXData.ListItems.Add(loopCount, , "")
            Call lstYData.ListItems.Add(loopCount, , "")
        Next
    End If
    Exit Sub
Handle_Error:
    ' Reset the list to 0 elements and also the text box to an empty string.
    MsgBox ("Error: " & Err.des)
    Call lstXData.ListItems.Clear
    Call lstYData.ListItems.Clear
    txtNumDataPts.Text = ""
End Sub

Private Sub cmdEvaluate_Click()
    ' Dim R As Range
    Dim XDataInterp As Variant ' Result variable object
    Dim loopCount As Integer ' A variable used for loop count
    Dim item As ListItem ' Temporary variable to store data in list box
    Dim XData() As Double ' X value of data points, passed to COM object
    Dim YData() As Double ' Y value of data points, passed to the COM object
    Dim XInterp() As Double ' X value of interpolation points, passed to COM
                            ' object
    Dim Yi As Variant ' Y value of interpolation points, obtained from COM
                      ' object as ouput value

    ' Set dimensions of the input and ouput data based on user inputs (number
    ' of data points and number of interpolation points).
    ReDim XData(1 To lstXData.ListItems.Count)
    ReDim YData(1 To lstYData.ListItems.Count)
    ReDim XInterp(1 To lstInterp.ListItems.Count)
    ReDim Yi(1 To lstInterp.ListItems.Count)
```

```
    ' Collect the Data and set the XData, YData, XInterp matrices accordingly
    For loopCount = 1 To lstXData.ListItems.Count
        XData(loopCount) = CDbl(lstXData.ListItems.item(loopCount))
        YData(loopCount) = CDbl(lstYData.ListItems.item(loopCount))
    Next
    For loopCount = 1 To lstInterp.ListItems.Count
        XInterp(loopCount) = CDbl(lstInterp.ListItems.item(loopCount))
        Yi(loopCount) = -1
    Next

    ' Check if the object was created properly.
    ' If not, go to the error handling routine.

    If theInterp Is Nothing Then GoTo Exit_Form

    ' If there is an error, continue with the code.
    On Error GoTo Handle_Error

    'Compute Curve Fitting Data
    Call theInterp.UnivariateInterpolation(1,Yi,XData,YData,XInterp,_
                                           chkPlot.Value)

    'Call lstInterp.ListItems.Clear
    For loopCount = LBound(Yi, 2) To UBound(Yi, 2)
        Set item = lstInterp.ListItems(loopCount)
        Call item.ListSubItems.Add(, , Format(Yi(1, loopCount), "##.###"))
    Next
    Call lstInterp.Refresh
    GoTo Exit_Form
Handle_Error:
    ' Error handling routine
    MsgBox ("Error: " & Err.Description)
Exit_Form:
End Sub
```

Matrix Calculator

This example shows how to encapsulate MATLAB utilities that perform basic matrix arithmetic. It includes M-code that performs matrix addition, subtraction, multiplication, division and left division and a function to evaluate the eigenvalues for a matrix. The example shows how to create the COM component using MATLAB Builder for .NET and how to use the COM component in a Visual Basic application independent of MATLAB.

Note This example assumes that you have downloaded the M-code from `http://www.mathworks.com/matlabcentral/` to the *`matlab/work`* directory. To get the download, search the `File Exchange` at `matlabcentral` for `MatrixArith`.

The example includes the following tasks:

- "Building the Component" on page 11-31
- "Using the Component in Visual Basic" on page 11-32
- "Creating the Visual Basic Form" on page 11-33

Building the Component

To build the component:

1. At the MATLAB command prompt, change directories to *`matlab/work`*`/MatrixArith`.

2. If you have not already done so, execute the following command in MATLAB:

   ```
   mbuild -setup
   ```

   Be sure to choose a supported compiler. See "Compiler Requirements" on page 7-2.

3. Enter the command deploytool to open the Deployment Tool dialog box.

4. Create a project with the following settings:

Setting	Value
Project name	matrixMath
Class name	matrixMathclass
Project directory	The name of your work directory followed by the Project name.
Show verbose output	Selected

5 Locate your work directory and navigate to the matrixMath directory, which contains the M-files needed for the component.

6 Add the following files to the project:

- addMatrices.m
- divideMatrices.m
- eigenValue.m
- leftDivideMatrices.m
- multiplyMatrices.m
- subtractMatrices.m

7 Build the component by clicking the Build button in the Deployment Tool toolbar.

   The build process begins, and a log of the build appears in the Output pane of the Deployment Tool dialog box. The files that are needed for the component are copied to two newly created directories, src and distrib, in the matrixMath directory. A copy of the build log is placed in the src directory.

Using the Component in Visual Basic

You can call the component from any application that supports COM. Follow these steps to create a Visual Basic project and add references to the necessary libraries.

1 Start Visual Basic.

2 Create a new Standard EXE project.

3 Click **Project > References**.

4 Ensure that the following libraries are in the project:

```
MatrixMath 1.0 Type Library

MWComUtil 7.5 Type Library
```

Note If you do not see these libraries, you may not have registered the libraries using `mwregsvr`. Refer to “Component Registration” on page 12-4 for information on this.

Creating the Visual Basic Form

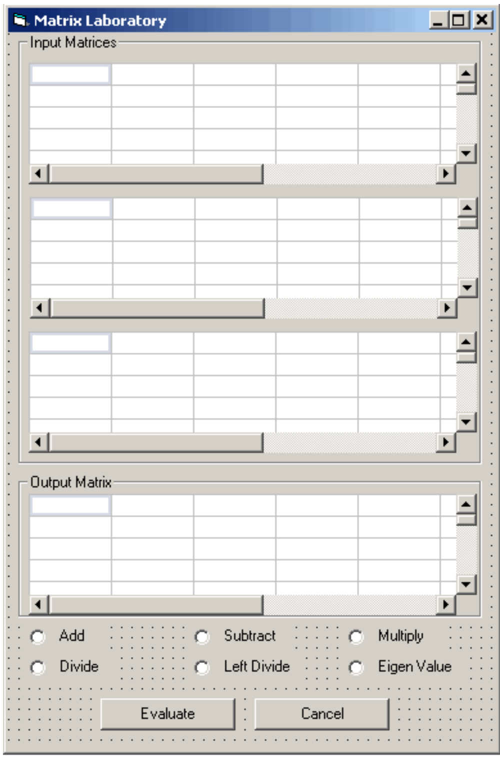
The next step creates a front end or a Visual Basic form for the application. End users enter data in this form.

Follow these steps to create a new user form and populate it with the necessary controls:

1 Click **Projects > Component**. Alternatively, press **Ctrl+T**.

2 Make sure that **Microsoft Windows Common Controls 6.0** are selected. You will use the `Spreadsheet` control from this component library.

3 Add a series of controls to the blank form to create an interface as shown in the next figure.



4 One of the main components used in the Visual Basic form is a `Spreadsheet` component. For each `Spreadsheet` component, set properties as follows:

Property	Original Value	New Value
`DisplayColumnHeaders`	`True`	`False`
`DisplayHorizontalScrollBar`	`True`	`False`
`DisplayRowHeaders`	`True`	`False`
`DisplayTitleBar`	`True`	`False`
`DisplayToolBar`	`True`	`False`
`DisplayVerticalScrollBar`	`True`	`False`

Property	Original Value	New Value
MaximumWidth	80%	100%
ViewableRange	1:65536	A1:E5

A consolidated list of components added to the form and the properties modified is as follows:

Control Type	Control Name	Properties	Purpose
Form	frmMatrixMath	Caption = Matrix Laboratory	Container for all components
Frame	frmInput	Caption = Input Data Points	Groups all input controls
Frame	frmOutput	Caption = Output Coefficients	Groups all output controls
Spreadsheet	sheetMat1	Refer to previous table.	Accepts input matrix 1 from user
Spreadsheet	sheetMat2	Refer to previous table.	Accepts input matrix 2 from user
Spreadsheet	sheetMat3	Refer to previous table.	Accepts input matrix 3 from user
Spreadsheet	sheetResultMat	Refer to previous table.	Displays result matrix
Label	lblAdd	Caption = Add	Labels **Add** option button
OptionButton	optOperation	Index = 0	Option button to perform addition
Label	lblSub	Caption = Subtract	Labels **Subtract** option button
OptionButton	optOperation	Index = 1	Option button to perform subtraction
Label	lblMult	Caption = Multiply	Labels **Multiply** option button

Control Type	Control Name	Properties	Purpose
OptionButton	optOperation	Index = 2	Option button to perform multiplication
Label	lblDivide	Caption = Divide	Labels **Divide** Option button
OptionButton	optOperation	Index = 3	Option button to perform division
Label	lblLeftDivide	Caption = Left Divide	Labels **Left Divide** Option button
OptionButton	optOperation	Index = 4	Option button to perform left division
Label	lblEig	Caption = Eigenvalue	Labels **Eigenvalue** Option button
OptionButton	optOperation	Index = 5	Option button to calculate Eigenvalue of first matrix
CommandButton	cmdEvaluate	Caption = Evaluate Default = True	Executes function
CommandButton	cmdCancel	Caption = Cancel Cancel = True	Dismisses dialog box without executing function

5 When the design is complete, save the project by clicking **File > Save**. When prompted for the project name, type MatrixMathVB.vbp, and for the form, type frmMatrixMath.frm.

6 To write the underlying code, right-click **frmMatrixMath** in the Project window, and click **View Code**.

The following code listing shows the code to implement. Note that this code references the control and variable names listed above. If you have given a different name to any of the controls or any global variable, change this code to reflect the differences.

```
Dim theMatCal As matrixMath.matrixMath

Private Sub Form_Initialize()
' Create an instance of the COM object and set the MWArray flags.
' If this fails, exit from the form.
On Error GoTo exit_form
    ' Create the object.
    Set theMatCal = New matrixMath.matrixMath
    ' Force the input to be of type double.
    theMatCal.MWFlags.DataConversionFlags.CoerceNumericToType = mwTypeDouble
    ' Set the AutoResizeOutput flag to True, so that you do not have to specify
    ' the size of the output variable as returned by the COM object.
    theMatCal.MWFlags.ArrayFormatFlags.AutoResizeOutput = True
    ' Get the results in a Matrix format.
    theMatCal.MWFlags.ArrayFormatFlags.OutputArrayFormat =_
mwArrayFormatMatrix
    Exit Sub
exit_form:
    ' Error handling routine. Since no object is created, display error '
    'message and unload the form.
    MsgBox ("Error: " & Err.Description)
    Unload Me
End Sub

Private Sub Form_Load()
    ' Set the run time properties for all the components.
    frmInputs.TabIndex = 1
    sheetMat1.AutoFit = True

    ' Set the tab order for each component and the viewable range.
    ' If you need a larger viewable range, you might want to turn the
    ' horizontal and vertical scroll bars to TRUE.
    sheetMat1.TabStop = True
    sheetMat1.TabIndex = 1
    sheetMat1.Width = 4875
    sheetMat1.ViewableRange = "A1:E5"

    sheetMat2.TabStop = True
    sheetMat2.TabIndex = 2
    sheetMat2.Width = 4875
```

```
    sheetMat2.ViewableRange = "A1:E5"

    sheetMat3.TabStop = True
    sheetMat3.TabIndex = 3
    sheetMat3.Width = 4875
    sheetMat3.ViewableRange = "A1:E5"

    sheetResultMatTabStop = False
    sheetResultMatTabIndex = 1
    sheetResultMatWidth = 4875
    sheetResultMat.ViewableRange = "A1:E5"

    frmOutput.TabIndex = 2
    optOperation(0).TabIndex = 3
    optOperation(1).TabIndex = 4
    optOperation(2).TabIndex = 5
    optOperation(3).TabIndex = 6
    optOperation(4).TabIndex = 7
    optOperation(5).TabIndex = 8
End Sub

Private Sub cmdCancel_Click()
    ' When the user clicks on the Cancel button, unload the form.
    Unload Me
End Sub

Private Sub cmdEval_Click()
    ' Declare the variables to be used in the code
    Dim data1 As Range
    ' This is the temporary variable that holds the value entered in
    ' the spreadsheet.

    'Dim finalRows As Double ' The number of
    'Dim finalCols As Double

    ' Dim tempVal As Double
    Dim matArray1 As Variant ' Variable to hold the value of input Matrix 1,
                             ' passed to the COM object directly.
    Dim matArray2 As Variant ' Variable to hold the value of input Matrix 1,
                             ' passed via varArg variable.
```

```
Dim matArray3 As Variant ' Variable to hold the value of input Matrix 1,
                         ' passed via varArg variable.
Dim varArg(2) As Variant ' Variable to hold the value of input Matrix 1,,
' contains the two optional matrices and is passed to the COM object.

'Dim mat1() As Double
'Dim mat1Dimension2() As Variant

Dim tempRange As Range ' Take the range value as obtained from the
                       ' user input into a temporary range.
Dim resultMat As Variant ' Variable to take the result matrix in
Dim msg As String ' The message thrown by the COM object is taken
                  ' in this variable.

Call sheetResultMat.ActiveSheet.UsedRange.Clear

' Check if the COM object was created properly.
' If not exit
If theMatCal Is Nothing Then GoTo exit_form

' Get the used range of data from the sheetMat1, which will then be
' converted into matArray1.
Set data1 = sheetMat1.ActiveSheet.UsedRange

'finalRows = data1.Rows.Count
'finalCols = data1.Columns.Count

'ReDim mat1(1 To data1.Rows.Count)
'ReDim mat1Dimension2(1 To data1.Columns.Count)
ReDim matArray1(1 To data1.Rows.Count, 1 To data1.Columns.Count) As_
Double
For RowCount = 1 To data1.Rows.Count
    For ColCount = 1 To data1.Columns.Count
        ' Extract the values and populate input matrix 1.
        Set tempRange = data1.Cells(RowCount, ColCount)
        'tempVal = tempRange.Value
        'matArray1(RowCount, ColCount) = tempVal
        matArray1(RowCount, ColCount) = tempRange.Value
        'Set mat1(ColCount) = tempRange.Value
    Next ColCount
```

```
        ' mat1Dimension2(RowCount) = mat1()
    Next RowCount

    Set data1 = sheetMat2.ActiveSheet.UsedRange
    If (Not (data1.Value = "")) Then
        ReDim matArray2(1 To data1.Rows.Count, 1 To data1.Columns.Count) As_
        Double
        For RowCount = 1 To data1.Rows.Count
            For ColCount = 1 To data1.Columns.Count
                Set tempRange = data1.Cells(RowCount, ColCount)
                tempVal = tempRange.Value
                matArray2(RowCount, ColCount) = tempVal
            Next ColCount
        Next RowCount
        finalCols = data1.Columns.Count
        varArg(0) = matArray2
    End If

    Set data1 = sheetMat3.ActiveSheet.UsedRange
    If (Not (data1.Value = "")) Then
        ReDim matArray3(1 To data1.Rows.Count, 1 To data1.Columns.Count) As_
Double
        For RowCount = 1 To data1.Rows.Count
            For ColCount = 1 To data1.Columns.Count
                Set tempRange = data1.Cells(RowCount, ColCount)
                tempVal = tempRange.Value
                matArray3(RowCount, ColCount) = tempVal
            Next ColCount
        Next RowCount
        finalCols = data1.Columns.Count
        varArg(1) = matArray3
    End If

    ' Based on the operation selected by the user, call the appropriate method
    ' from the COM object.
    If optOperation.Item(0).Value = True Then ' Add
        Call theMatCal.addMatrices(2, resultMat, msg, matArray1, varArg)
    ElseIf optOperation.Item(1).Value = True Then ' Subtract
        Call theMatCal.subtractMatrices(2, resultMat, msg, matArray1, varArg)
    ElseIf optOperation.Item(2).Value = True Then ' Multiply
```

```
            Call theMatCal.multiplyMatrices(2, resultMat, msg, matArray1, varArg)
        ElseIf optOperation.Item(3).Value = True Then ' Divide
            Call theMatCal.divideMatrices(2, resultMat, msg, matArray1, varArg)
        ElseIf optOperation.Item(4).Value = True Then ' Left Divide
            Call theMatCal.leftDivideMatrices(2, resultMat, msg, matArray1,_
            varArg)
        ElseIf optOperation.Item(5).Value = True Then ' Eigen Value
            Call theMatCal.eigenValue(2, resultMat, msg, matArray1)
        End If

        ' If the result matrix is a scalar double, display it in the first cell.
        If (VarType(resultMat) = vbDouble) Then
            Set tempRange = sheetResultMat.Cells(1, 1)
            tempRange.Value = resultMat

        ' If the result matrix is not a scalar double, loop through it to display
        ' all the elements.
        Else
            For RowCount = 1 To UBound(resultMat, 1)
                For ColCount = 1 To UBound(resultMat, 2)
                    Set tempRange = sheetResultMat.Cells(RowCount, ColCount)
                    tempRange.Value = resultMat(RowCount, ColCount)
                Next ColCount
            Next RowCount
        End If
        Exit Sub
    exit_form:
        MsgBox ("Error: " & Err.Description)
        Unload Me
    End Sub

    ' If the user changes the operation, clear the result matrix.
    Private Sub optOperation_Click(Index As Integer)
        Call sheetResultMat.ActiveSheet.Cells.Clear
    End Sub
```

Curve Fitting

This example is a demonstration of the optimal fitting of a nonlinear function to a set of data, using the curve-fitting demo `fitfun` provided with MATLAB. It uses `fminsearch`, an implementation of the Nelder-Mead simplex (direct search) algorithm, to minimize a nonlinear function of several variables.

This example shows you how to create the COM component using MATLAB Builder for .NET and how to use this COM component in a Visual Basic application independent of MATLAB.

Note This example assumes that you have downloaded the M-code from `http://www.mathworks.com/matlabcentral/` to the *`matlab`*`/`*`work`* directory. To get the download, search the `File Exchange` at `matlabcentral` for `COM Builder Demo: Curve Fitting`.

The example includes the following tasks:

- "Building the Component" on page 11-42
- "Building the Project" on page 11-43
- "Using the Component in Visual Basic" on page 11-43
- "Creating the Visual Basic Form" on page 11-44

Building the Component

To build the component:

1. At the MATLAB command prompt, change directories to *`matlab`*`/`*`work`*.
2. If you have not already done so, execute the following command in MATLAB:

   ```
   mbuild -setup
   ```

   Be sure to choose a supported compiler. See "Compiler Requirements" on page 7-2.

3 Enter the `deploytool` command to open the Deployment Tool dialog box.

4 Create a project with the following settings:

Project name	`CurveFit`
Class name	`CurveFitclass`

Building the Project

To build the project:

1 In the Deployment Tool dialog box, add `fitfun.m` and `fitdemo.m` from the directory *`matlab`*`/`*`work`*`/CurveFitDemo`.

2 Click the Build button in the toolbar.

The component is created and placed in the `distrib` directory within the `Class`directory.

Using the Component in Visual Basic

You can call the component from any application that supports COM.

Follow these steps to create a Visual Basic project and add references to the necessary libraries.

1 Start Visual Basic.

2 Create a new Standard EXE project.

3 Click **Project > References**.

4 Ensure that the following libraries are included in the project:

```
CurveFit 1.0 Type Library

MWComUtil 7.5 Type Library
```

Note If you do not see these libraries, you may not have registered the libraries using mwregsvr. Refer to "Component Registration" on page 12-4 for information.

Creating the Visual Basic Form

The next step is to create a front end or a Visual Basic form for the application. End users enter data on the form.

Follow these steps to create a new user form and populate it with the necessary controls.

1 Click **Projects > Component**. Alternatively, press **Ctrl+T**.

2 Make sure that **Microsoft Windows Common Controls 6.0** are selected. You will use the ListView control from this component library.

3 Add a series of controls to the blank form to create an interface as shown in the next figure.

The following table shows the components and properties that are required:

Control Type	Control Name	Properties	Purpose
Form	frmCurveFit	Caption = Curve Fitting	Container for all components.
Frame	frmInput	Name = frmInput* Caption = Input Data Points	Groups all input controls.
Frame	frmOutput	Name = frmOutput* Caption = Output Coefficients	Groups all output controls.

Control Type	Control Name	Properties	Purpose
Label	lblNumDataPoints	Caption = Number of Data Points	Labels the text box that takes the number of data points the user wants to enter.
TextBox	txtNumOfDatPoints	Text =	Holds number of data points the user wants to enter. Sets size of list box added later.
ListView	lstXData	Name = lstXData GridLines = TrueLabel Edit = lvwAutomatic View = lvwReport	X-data values. Set the view type to lvwReport to enable user to add data to the list view.
ListView	lxtYData	Name = lstYData GridLines = TrueLabel Edit = lvwAutomatic View = lvwReport	Y-data values.
Label	lblCoeff1*	Caption = Co-efficient 1	Labels text box for coefficient 1.
Label	lblCoeff2	Caption = Co-efficient 2	Labels text box for coefficient 2.
TextBox	txtCoeff1	Text =	Displays value of coefficient 1 as calculated by the COM module.
TextBox	txtCoeff2	Text =	Displays value of coefficient 2 as calculated by the COM module.

Control Type	Control Name	Properties	Purpose
`Label`	`lblLambda1*`	Caption = `Lambda 1`	Labels text box for lambda 1.
`Label`	`lblLambda2`	Caption = `Lambda 2`	Labels text box for lambda 2.
`TextBox`	`txtLambda1`	Text =	Displays value of lambda 1 as calculated by the COM module.
`TextBox`	`txtLambda2`	Text =	Displays value of lambda 2 as calculated by the COM module.
`CommandButton`	`cmdEvaluate`	Caption = `Evaluate` Default = `True`	Executes function.
`CommandButton`	`cmdCancel`	Caption = `Cancel` Cancel = `True`	Dismisses dialog box without executing function.

4 When the design is complete, save the project by clicking **File > Save**.

5 When prompted for the project name, type `CurveFitExample.vbp`, and for the form, type `frmCurveFit.frm`.

6 In the Project window, right-click `frmCurveFit` and click **View Code**.

The following code listing shows the code to implement. Note that this code references the control and variable names listed above. If you have given a different name to any of the controls or any global variable, change this code to reflect the differences.

```
Dim theFit As CurveFit.CurveFit ' Variable to hold the COM Object

' This routine is exectued when the form is initialized.
Private Sub Form_Initialize()
```

```
' If the initialize routine fails, handle it accordingly.
On Error GoTo Exit_Form
    ' Create the COM object
    Set theFit = New CurveFit.CurveFit
    ' Set the flags such that the output is transposed.
    theFit.MWFlags.ArrayFormatFlags.TransposeOutput = True
    Exit Sub
Exit_Form:
    ' Display the error message and Unload the form if object
creation failed
    MsgBox ("Error: " & Err.Description)
    MsgBox ("Error: Could not create the COM object")
    Unload Me
End Sub

Private Sub Form_Load()
On Error GoTo Exit_Form
    ' Set the runtime properties of the components

    ' Set the headers of the column
    Call lstXData.ColumnHeaders.Add(, , "X Data")
    Call lstYData.ColumnHeaders.Add(, , "Y Data")

    ' Make labeledit property automatic so that you edit the label.
    lstXData.LabelEdit = lvwAutomatic
    lstYData.LabelEdit = lvwAutomatic

    ' Make the grid lines for the listbox visible.
    lstXData.GridLines = True
    lstYData.GridLines = True
    Exit Sub
Exit_Form:
    ' Error handling routine. Since cannot load the form,
    ' display the error message and unload the program.
    MsgBox ("Error: Could not load the form")
    MsgBox ("Error: " & Err.Description)
    Unload Me
End Sub

Private Sub cmdCancel_Click()
```

```
    ' If the user hits the cancel button, unload the form.
    Unload Me
End Sub

Private Sub txtNumOfDataPoints_Change()
    ' If user changes number of data points, clear XData and YData
    ' listboxes. Provide enough spaces for given number of points.
    Dim loopCount As Integer
    Call lstXData.ListItems.Clear
    Call lstYData.ListItems.Clear
    If (txtNumOfDataPoints.Text = "") Then
        Exit Sub
    End If
    For loopCount = 1 To CInt(txtNumOfDataPoints.Text)
        lstXData.ListItems.Add (loopCount)
        lstYData.ListItems.Add (loopCount)
    Next loopCount
End Sub

Private Sub cmdEvaluate_Click()
    Dim loopCount As Integer ' loop counter
    Dim numOfData As Integer ' variable to hold the number of data
                             ' points the user has entered
    Dim XData() As Double ' Column Vector for XData, will be passed
                          ' as input to the COM method.
    Dim YData() As Double ' Column Vector for YData, will be passed
                          ' as input to the COM method.
    Dim Coeff As Variant ' Coefficient values will be returned by
                         ' the COM method in this variable.
    Dim Lambda As Variant ' Lambda values will be returned by the
                          ' COM method in this variable.

    ' If there is an error, handle it accordingly.
On Error GoTo Handle_Error
    If txtNumOfDataPoints.Text = "" Then
        Exit Sub
    End If
    ' Get the number of data points.
    numOfData = CInt(txtNumOfDataPoints.Text)
    ReDim XData(1 To numOfData) As Double
```

```
    ReDim YData(1 To numOfData) As Double
    ' Read the input data into respective double arrays.
    For loopCount = 1 To numOfData
        XData(loopCount) = lstXData.ListItems.Item(loopCount)
        YData(loopCount) = lstYData.ListItems.Item(loopCount)
    Next loopCount

    ' Call the COM method
    Call theFit.fitdemo(2, Coeff, Lambda, XData, YData)

    ' Display values of coefficients returned by the COM method.
    txtCoeff1.Text = CStr(Format(Coeff(1, 1), "##.####"))
    txtCoeff2.Text = CStr(Format(Coeff(1, 2), "##.####"))
    txtLambda1.Text = CStr(Format(Lambda(1, 1), "##.####"))
    txtLambda2.Text = CStr(Format(Lambda(1, 2), "##.####"))
    Exit Sub
Handle_Error:
    ' Error handling routine
    MsgBox ("Error: " & Err.Description)
End Sub
```

Bouncing Ball Simulation

This example is adapted from the `ballode` demo provided with MATLAB. It demonstrates repeated event location, where the conditions are changed after each terminal event.

This demo computes 10 bounces with calls to `ode23`, which is a MATLAB function. A user-specified damping factor after each bounce attenuates the speed of the ball. The trajectory is plotted using the output function `odeplot`. In addition to the damping factor, the user can also provide the initial velocity, the maximum number of bounce to track, and the maximum time until demo is completed.

This example shows you how to create the COM component using MATLAB Builder for .NET and how to use this COM component in a Visual Basic application independent of MATLAB.

Note This example assumes that you have downloaded the M-code to the *`matlab`*`/`*`work`* directory.

The example includes the following tasks:

- "Building the Component" on page 11-50
- "Using the Component in Visual Basic" on page 11-51
- "Creating the Visual Basic Form" on page 11-52

Building the Component

To build the component:

1. At the MATLAB command prompt change directories to *`matlab`*`/`*`work`*`/BallODE`.

2. If you have not already done so, execute the following command in MATLAB:

```
mbuild -setup
```

Be sure to choose a supported compiler. See "Compiler Requirements" on page 7-2.

3. Enter the command `deploytool` to open the Deployment Tool dialog box.

4. Use the Deployment Tool to create a project with the following settings:

Setting	Value
Project name	`bouncingBall`
Class name	`bouncingBallclass`
Project directory	The name of your work directory followed by the component name.
Show verbose output	Selected

5. Locate your work directory, navigate to *`matlab`*`/`*`work`*`/BallODE`, and add `ballode.m` to the project.

6. Build the component by clicking the Build button in the Deployment Tool toolbar.

   The build process begins, and a log of the build appears in the Output pane of the Deployment Tool dialog box. The files that are needed for the component are copied to two newly created directories, `src` and `distrib`, in the `bouncingBall` directory. A copy of the build log is placed in the `src` directory.

Using the Component in Visual Basic

You can call the component from any application that supports COM.

Follow these steps to create a Visual Basic project and add references to the necessary libraries.

1. Start Visual Basic.

2. Create a new Standard EXE project.

3. Click **Project > References**.

4 Select the following libraries:

- `bouncingBall 1.0 Type Library`

  (If you named your class something other than `bouncingBall` or gave a different version number, click and use the appropriate component and corresponding type library.)

- `MWComUtil 7.5 Type Library`

Note If you do not see these libraries, you may not have registered the libraries using `mwregsvr`. Refer to "Component Registration" on page 12-4 for information on this.

Creating the Visual Basic Form

The next task is to create a front end or a Visual Basic form for the application. End users enter data with this form.

Follow these steps to create a new user form and populate it with the necessary controls.

1 Click **Projects > Component**.

  Alternatively, press **Ctrl+T**.

2 Check that **Microsoft Windows Common Controls 6.0** is selected. You will use the `ListView` control from this component library.

3 Add a series of controls to the blank form to create an interface with the properties listed in the following table:

Control Type	Control Name	Properties	Purpose
`Form`	`frmBallOde`	Caption = `Bouncing Ball ODE`	Container for all components.
`Frame`	`frmInput`	Name = `frmInput*` Caption = `Input Data Points`	Groups all input controls.

Control Type	Control Name	Properties	Purpose
Frame	frmOutput	Name = frmOutput* Caption = Output Coefficients	Groups all output controls.
Label	lblInitVal	Caption = Initial Velocity	Labels the text box txtInitVal.
TextBox	txtInitVal	Text =	Holds initial velocity by which ball is thrown into the air.
Label	lblDamp	Caption = Damping Factor	Labels the text box txtDamp.
TextBox	txtDamp	Text =	Holds damping factor for the bounce, that is, the factor by which the speed of the ball is reduced after it bounces.
Label	lblIter	Caption = Number of Bounces	Labels the text box txtIter.
TextBox	txtIter	Text =	Holds number of iterations or bounces to track.
Label	lblFinalTime	Caption = Maximum Time	Labels the text box txtFinalTime.
TextBox	txtFinalTime	Text =	Stores time until demo is completed.
ListView	lstBounce	Name = lstBounce GridLines = True LabelEdit = lvwManual View = lvwReport	Displays time stamp when ball bounces off the ground.

Control Type	Control Name	Properties	Purpose
CommandButton	cmdEvaluate	Caption = Evaluate Default = True	Executes function.
CommandButton	cmdCancel	Caption = Cancel Cancel = True	Dismisses dialog box without executing function.

4 When the design is complete, save the project by clicking **File > Save**. When prompted for the project name, type `BallOde.vbp`, and for the form, type `frmBallOde.frm`.

5 In the Project dialog box right-click `frmBallOde` and click **View Code**.

The following code listing shows the code to implement. Note that this code references the control and variable names listed above. If you have given a different name to any of the controls or any global variable, change this code to reflect the differences.

```
Private theBall As Variant ' Variable to hold the COM object.

Private Sub cmdCancel_Click()
    ' If the user presses the Cancel button, unload the form.
    Unload Me
End Sub

Private Sub Form_Initialize()
    Dim Len1 As Long ' Used to set length of columns for list box.
    Dim Len2 As Long ' Used to set length of columns for list box.
    On Error GoTo Handle_Error
    ' Set length of the each column based on length of the listbox
    ' such that the two columns span the maximum area without
    ' creating a horizontal scroll bar.
    Len2 = lstBounce.Width / 2
    Len1 = (lstBounce.Width - Len2) - 300

    ' Add column headers to each column in the list box.
    Call lstBounce.ColumnHeaders.Add(, , "Bounce", Len1)
    Call lstBounce.ColumnHeaders.Add(, , "Time", Len2)
```

```
    ' Set tab indices for each component.
    txtInitVel.TabIndex = 1
    txtDamp.TabIndex = 2
    txtIter.TabIndex = 3
    txtFinalTime.TabIndex = 4
    cmdEvaluate.TabIndex = 5
    cmdCancel.TabIndex = 6
    lstBounce.TabStop = False

    ' Create the COM object
    ' If there is an error, handle it accordingly.
    Set theBall = CreateObject("bouncingBall.bouncingBall.1_0")
    Exit Sub
Handle_Error:
    ' Error handling code
    MsgBox ("Error " & Err.Description)
End Sub
Private Sub cmdEvaluate_Click()
    ' Dim R As Range
    Dim zeroTime As Variant ' Result variable object.
    Dim loopCount As Integer
    Dim item As ListItem

    ' Check if the object was created properly.
    ' If not, go to the error handling routine.
    If theBall Is Nothing Then GoTo Exit_Form

    ' If there is an error, continue with the code.
    On Error Resume Next

    ' Process inputs
    ' If the user does not provide the values for input parameters,
    ' use the default values.
    If txtDamp.Text = Empty Then
        txtDamp.Text = 0.9
    End If
    If txtInitVel.Text = Empty Then
        txtInitVel.Text = 20
    End If
    If txtIter.Text = Empty Then
```

```
        txtIter.Text = 15
    End If
    If txtFinalTime.Text = Empty Then
        txtFinalTime.Text = 20
    End If

    'Compute Bouncing ball data
    Call theBall.ballode(1, zeroTime, CDbl(txtIter.Text),_
    CDbl(txtDamp.Text), CDbl(txtFinalTime.Text),_
    CDbl(txtInitVel.Text))

    ' Display the output values (time stamp when ball bounces on
    ' the ground).
    Call lstBounce.ListItems.Clear
    For loopCount = LBound(zeroTime, 1) To UBound(zeroTime, 1)
        Set item = lstBounce.ListItems.Add(, , Format(loopCount))
        Call item.ListSubItems.Add(, , Format(zeroTime(loopCount,_
        1), "##.###"))
    Next
    Call lstBounce.Refresh

    GoTo Exit_Form
Handle_Error:
    ' Error handling routine
    MsgBox (Err.Description)
Exit_Form:
End Sub
```

12

How MATLAB Builder for .NET Creates COM Components

Overview of Internal Processes (p. 12-2)	Describes the steps in the build process
Component Registration (p. 12-4)	Describes the registration process for COM components created by MATLAB Builder for .NET.
Data Conversion Rules (p. 12-8)	Converting between MATLAB and COM variants.
Calling Conventions (p. 12-22)	Describes the calling conventions for COM components created by MATLAB Builder for .NET

Overview of Internal Processes

The process of creating a MATLAB Builder for .NET component is completely automatic from a user point of view. You specify a list of M-files to process and a few additional pieces of information, such as the component name, the class names, and the version number.

The internal build process involves the following steps:

1 "Code Generation" on page 12-2

2 "Create Interface Definitions" on page 12-2

3 "C++ Compilation" on page 12-3

4 "Linking and Resource Binding" on page 12-3

5 "Registration of the DLL" on page 12-3

Code Generation

The first step in the build process generates all source code and other supporting files needed to create the component. It also creates the main source file (`mycomponent_dll.cpp`) containing the implementation of each exported function of the DLL. The compiler additionally produces an Interface Description Language (IDL) file (`mycomponent_idl.idl`), containing the specifications for the component's type library, interface, and class, with associated GUIDs. (GUID is an acronym for Globally Unique Identifier, a 128-bit integer guaranteed always to be unique.)

Created next are the C++ class definition and implementation files (`myclass_com.hpp` and `myclass_com.cpp`). In addition to these source files, the compiler generates a DLL exports file (`mycomponent.def`), a resource script (`mycomponent.rc`), and a Component Technology File (`mycomponent.ctf`). See the MATLAB Compiler documentation for a discussion of `ctf` files.

Create Interface Definitions

The second step of the build process invokes the IDL compiler on the IDL file generated in step 1 (`mycomponent_idl.idl`), creating the interface header

file (mycomponent_idl.h), the interface GUID file (mycomponent_idl_i.c), and the component type library file (mycomponent_idl.tlb). The interface header file contains type definitions and function declarations based on the interface definition in the IDL file. The interface GUID file contains the definitions of the GUIDs from all interfaces in the IDL file. The component type library file contains a binary representation of all types and objects exposed by the component.

C++ Compilation

The third step compiles all C/C++ source files generated in steps 1 and 2 into object code. One additional file containing a set of C++ template classes (mclcomclass.h) is included at this point. This file contains template implementations of all necessary COM base classes, as well as error handling and registration code.

Linking and Resource Binding

The fourth step produces the finished DLL for the component. This step invokes the linker on the object files generated in step 3 and the necessary MATLAB libraries to produce a DLL component (mycomponent_1_0.dll). The resource compiler is then invoked on the DLL, along with the resource script generated in step 1, to bind the type library file generated in step 2 into the completed DLL.

Registration of the DLL

The final build step registers the DLL on the system, as described in “Component Registration” on page 12-4.

Component Registration

When MATLAB Builder for .NET creates a component, it automatically generates a binary file called a *type library*. As a final step of the build, this file is bound with the resulting DLL as a resource.

Self-Registering Components

.NET Builder COM components are all *self-registering*. A self-registering component contains all the necessary code to add or remove a full description of itself to or from the system registry. The `mwregsvr` utility, distributed with the MCR, registers self-registering DLLs. For example, to register a component called `mycomponent_1_0.dll`, issue this command at the DOS command prompt.

```
mwregsvr mycomponent_1_0.dll
```

When `mwregsvr` completes the registration process, it displays a message indicating success or failure. Similarly, the command

```
mwregsvr /u mycomponent_1_0.dll
```

unregisters the component.

A .NET Builder component installed onto a particular machine must be registered with `mwregsvr`. If you move a component into a different directory on the same machine, you must repeat the registration process. When deleting a component from a specific machine, first unregister it to ensure that the registry does not retain erroneous information.

Note The `mwregsvr` utility invokes a process that is similar to `regsvr32.exe`, except that `mwregsvr` does not require interaction with a user at the console. The `regsvr32.exe` process belongs to the Windows OS and is used to register dynamic-link libraries and ActiveX controls in the registry. This program is important for the stable and secure running of your computer and should not be terminated. You can use `regsvr32.exe` as an alternative to `mwregsvr` to register your library.

Globally Unique Identifier (GUID)

Information is stored in the registry as keys with one or more associated named values. The keys themselves have values of primarily two types: readable strings and GUIDs. (GUID is an acronym for Globally Unique Identifier, a 128-bit integer guaranteed always to be unique.)

.NET Builder automatically generates GUIDs for COM classes, interfaces, and type libraries that are defined within a component at build time, and codes these keys into the component's self-registration code.

The interface to the system registry is directory based. COM-related information is stored under a top-level key called `HKEY_CLASSES_ROOT`. Under `HKEY_CLASSES_ROOT` are several other keys under which .NET Builder writes component information.

See the following table for a list of the keys and their definitions.

Key	Definition
`HKEY_CLASSES_ROOT\CLSID`	Information about COM classes on the system. Each component creates a new key under `HKEY_CLASSES_ROOT\CLSID` for each of its COM classes. The key created has a value of the GUID that has been assigned the class and contains several subkeys with information about the class.
`HKEY_CLASSES_ROOT\Interface`	Information about COM interfaces on the system. Each component creates a new key under `HKEY_CLASSES_ROOT\Interface` for each interface it defines. This key has the value of the GUID assigned to the interface and contains subkeys with information about the interface.

Key	Definition
`HKEY_CLASSES_ROOT\TypeLib`	Information about type libraries on the system. Each component creates a key for its type library with the value of the GUID assigned to it. Under this key a new key is created for each version of the type library. Therefore, new versions of type libraries with the same name reuse the original GUID but create a new subkey for the new version.
`HKEY_CLASSES_ROOT\<ProgID>`, `HKEY_CLASSES_ROOT\<VerIndProgID>`	These two keys are created for the component's Program ID and Version Independent Program ID. These keys are constructed from strings of the following forms: *`component-name.class-name`* *`component-name.class-name version-number`*. These keys are useful for creating a class instance from the component and class names instead of the GUIDs.

Versioning

MATLAB Builder for .NET components support a simple versioning mechanism designed to make building and deploying multiple versions of the same component easy to implement. The version number of a component appears as part of the DLL name, as well as part of the version-dependent ID in the system registry.

When a component is created, you can specify a version number. (The default is 1.0.) During the development of a specific version of a component, the version number should be kept constant. When this is done, the MATLAB Compiler, in certain cases, reuses type library, class, and interface GUIDs for each subsequent build of the component. This avoids the creation of an excessive number of registry keys for the same component during multiple builds, as occurs if new GUIDs are generated for each build.

When a new version number is introduced, the MATLAB Compiler generates new class and interface GUIDs so that the system recognizes them as distinct from previous versions, even if the class name is the same. Therefore, once you deploy a built component, use a new version number for any changes made to the component. This ensures that after you deploy the new component, it is easy to manage the two versions.

The MATLAB Compiler implements the versioning rules for a specific component name, class name, and version number by querying the system registry for an existing component with the same name:

- If an existing component has the same version, it uses the GUID of the existing component's type library. If the name of the new class matches the previous version, it reuses the class and interface GUIDs. If the class names do not match, it generates new GUIDs for the new class and interface.
- If it finds an existing component with a different version, it uses the existing type library GUID and creates a new subkey for the new version number. It generates new GUIDs for the new class and interface.
- If it does not find an existing component of the specified name, it generates new GUIDs for the component's type library, class, and interface.

Data Conversion Rules

This section describes the data conversion rules for COM components created with MATLAB Builder for .NET. These components are dual interface COM objects that support data types compatible with Automation.

Note *Automation* (formerly called OLE Automation) is a technology that allows software packages to expose their unique features to scripting tools and other applications. Automation uses the Component Object Model (COM), but may be implemented independently from other OLE features, such as in-place activation.

When a method is invoked on a .NET Builder component, the input parameters are converted to MATLAB internal array format and passed to the compiled MATLAB function. When the function exits, the output parameters are converted from MATLAB internal array format to COM Automation types.

The COM client passes all input and output arguments in the compiled MATLAB functions as type `VARIANT`. The COM `VARIANT` type is a union of several simple data types. A type `VARIANT` variable can store a variable of any of the simple types, as well as arrays of any of these values.

The Win32 Application Program Interface (API) provides many functions for creating and manipulating `VARIANT`s in C/C++, and Visual Basic provides native language support for this type. See the Visual Studio documentation for definitions and API support for COM `VARIANT`s. `VARIANT` variables are self describing and store their type code as an internal field of the structure.

Note This discussion of data refers to both `VARIANT` and `Variant` data types. `VARIANT` is the C++ name and `Variant` is the corresponding data type in Visual Basic.

See VARIANT Type Codes Supported on page 12-9 for a list of the `VARIANT` type codes supported by .NET Builder components.

See MATLAB to COM VARIANT Conversion Rules on page 12-11 and COM VARIANT to MATLAB Conversion Rules on page 12-15 for conversion rules between COM VARIANTs and MATLAB arrays.

VARIANT Type Codes Supported

VARIANT Type Code (C/C++)	C/C++ Type	Variant Type Code (Visual Basic)	Visual Basic Type	Definition
VT_EMPTY	-	vbEmpty	-	Uninitialized VARIANT
VT_I1	char	-	-	Signed one-byte character
VT_UI1	unsigned char	vbByte	Byte	Unsigned one-byte character
VT_I2	short	vbInteger	Integer	Signed two-byte integer
VT_UI2	unsigned short	-	-	Unsigned two-byte integer
VT_I4	long	vbLong	Long	Signed four-byte integer
VT_UI4	unsigned long	-	-	Unsigned four-byte integer
VT_R4	float	vbSingle	Single	IEEE four-byte floating-point value
VT_R8	double	vbDouble	Double	IEEE eight-byte floating-point value
VT_CY	CY+	vbCurrency	Currency	Currency value (64-bit integer, scaled by 10,000)
VT_BSTR	BSTR+	vbString	String	String value

VARIANT Type Codes Supported (Continued)

VARIANT Type Code (C/C++)	C/C++ Type	Variant Type Code (Visual Basic)	Visual Basic Type	Definition
VT_ERROR	SCODE+	vbError	-	A HRESULT (Signed four-byte integer representing a COM error code)
VT_DATE	DATE+	vbDate	Date	Eight-byte floating point value representing date and time
VT_INT	int	-	-	Signed integer; equivalent to type int
VT_UINT	unsigned int	-	-	Unsigned integer; equivalent to type unsigned int
VT_DECIMAL	DECIMAL+	vbDecimal	-	96-bit (12-byte) unsigned integer, scaled by a variable power of 10
VT_BOOL	VARIANT_BOOL+	vbBoolean	Boolean	Two-byte Boolean value (0xFFFF = True; 0x0000 = False)
VT_DISPATCH	IDispatch*	vbObject	Object	IDispatch* pointer to an object
VT_VARIANT	VARIANT+	vbVariant	Variant	VARIANT (can only be specified if combined with VT_BYREF or VT_ARRAY)

VARIANT Type Codes Supported (Continued)

VARIANT Type Code (C/C++)	C/C++ Type	Variant Type Code (Visual Basic)	Visual Basic Type	Definition
<*anything*>|VT_ARRAY				Bitwise combine VT_ARRAY with any basic type to declare as an array
<*anything*>|VT_BYREF				Bitwise combine VT_BYREF with any basic type to declare as a reference to a value

[+] Denotes Windows-specific type. Not part of standard C/C++.

MATLAB to COM VARIANT Conversion Rules

MATLAB Data Type	VARIANT Type for Scalar Data	VARIANT Type for Array Data	Comments
cell	A 1-by-1 cell array converts to a single VARIANT with a type conforming to the conversion rule for the MATLAB data type of the cell contents.	A multidimensional cell array converts to a VARIANT of type VT_VARIANT|VT_ARRAY with the type of each array member conforming to the conversion rule for the MATLAB data type of the corresponding cell.	

MATLAB to COM VARIANT Conversion Rules (Continued)

MATLAB Data Type	VARIANT Type for Scalar Data	VARIANT Type for Array Data	Comments
structure	VT_DISPATCH	VT_DISPATCH	A MATLAB struct array is converted to an MWStruct object. (See "Class MWStruct" on page 13-16.) This object is passed as a VT_DISPATCH type.
char	A 1-by-1 char matrix converts to a VARIANT of type VT_BSTR with string length = 1.	A 1-by-L char matrix is assumed to represent a string of length Lin MATLAB. This case converts to a VARIANT of type VT_BSTR with a string length = L. char matrices of more than one row, or of a higher dimensionality convert to a VARIANT of type VT_BSTR|VT_ARRAY. Each string in the converted array is of length 1 and corresponds to each character in the original matrix.	Arrays of strings are not supported as char matrices. To pass an array of strings, use a cell array of 1-by-L char matrices.
sparse	VT_DISPATCH	VT_DISPATCH	A MATLAB sparse array is converted to an MWSparse object. (See "Class MWSparse" on page 13-26.) This object is passed as a VT_DISPATCH type.

MATLAB to COM VARIANT Conversion Rules (Continued)

MATLAB Data Type	VARIANT Type for Scalar Data	VARIANT Type for Array Data	Comments
double	A real 1-by-1 double matrix converts to a VARIANT of type VT_R8. A complex 1-by-1 double matrix converts to a VARIANT of type VT_DISPATCH.	A real multidimensional double matrix converts to a VARIANT of type VT_R8|VT_ARRAY. A complex multidimensional double matrix converts to a VARIANT of type VT_DISPATCH.	Complex arrays are passed to and from compiled M-functions using the MWComplex class. See "Class MWComplex" on page 13-24.)
single	A real 1-by-1 single matrix converts to a VARIANT of type VT_R4. A complex 1-by-1 single matrix converts to a VARIANT of type VT_DISPATCH.	A real multidimensional single matrix converts to a VARIANT of type VT_R4|VT_ARRAY. A complex multidimensional single matrix converts to a VARIANT of type VT_DISPATCH.	Complex arrays are passed to and from compiled M-functions using the MWComplex class.
int8	A real 1-by-1 int8 matrix converts to a VARIANT of type VT_I1. A complex 1-by-1 int8 matrix converts to a VARIANT of type VT_DISPATCH.	A real multidimensional int8 matrix converts to a VARIANT of type VT_I1|VT_ARRAY. A complex multidimensional int8 matrix converts to a VARIANT of type VT_DISPATCH.	Complex arrays are passed to and from compiled M-functions using the MWComplex class.

MATLAB to COM VARIANT Conversion Rules (Continued)

MATLAB Data Type	VARIANT Type for Scalar Data	VARIANT Type for Array Data	Comments
uint8	A real 1-by-1 uint8 matrix converts to a VARIANT of type VT_UI1. A complex 1-by-1 uint8 matrix converts to a VARIANT of type VT_DISPATCH.	A real multidimensional uint8 matrix converts to a VARIANT of type VT_UI1|VT_ARRAY.A complex multidimensional uint8 matrix converts to a VARIANT of type VT_DISPATCH.	Complex arrays are passed to and from compiled M-functions using the MWComplex class.
int16	A real 1-by-1 int16 matrix converts to a VARIANT of type VT_I2. A complex 1-by-1 int16 matrix converts to a VARIANT of type VT_DISPATCH.	A real multidimensional int16 matrix converts to a VARIANT of type VT_I2|VT_ARRAY. A complex multidimensional int16 matrix converts to a VARIANT of type VT_DISPATCH.	Complex arrays are passed to and from compiled M-functions using the MWComplex class.
uint16	A real 1-by-1 uint16 matrix converts to a VARIANT of type VT_UI2. A complex 1-by-1 uint16 matrix converts to a VARIANT of type VT_DISPATCH.	A real multidimensional uint16 matrix converts to a VARIANT of type VT_UI2|VT_ARRAY. A complex multidimensional uint16 matrix converts to a VARIANT of type VT_DISPATCH.	Complex arrays are passed to and from compiled M-functions using the MWComplex class.

MATLAB to COM VARIANT Conversion Rules (Continued)

MATLAB Data Type	VARIANT Type for Scalar Data	VARIANT Type for Array Data	Comments
int32	A 1-by-1 int32 matrix converts to a VARIANT of type VT_I4. A complex 1-by-1 int32 matrix converts to a VARIANT of type VT_DISPATCH.	A multidimensional int32 matrix converts to a VARIANT of type VT_I4|VT_ARRAY. A complex multidimensional int32 matrix converts to a VARIANT of type VT_DISPATCH.	Complex arrays are passed to and from compiled M-functions using the MWComplex class.
uint32	A 1-by-1 uint32 matrix converts to a VARIANT of type VT_UI4. A complex 1-by-1 uint32 matrix converts to a VARIANT of type VT_DISPATCH.	A multidimensional uint32 matrix converts to a VARIANT of type VT_UI4|VT_ARRAY. A complex multidimensional uint32 matrix converts to a VARIANT of type VT_DISPATCH.	Complex arrays are passed to and from compiled M-functions using the MWComplex class.
Function handle	VT_EMPTY	VT_EMPTY	Not supported
Java class	VT_EMPTY	VT_EMPTY	Not supported
User class	VT_EMPTY	VT_EMPTY	Not supported
logical	VT_Bool	VT_Bool|VT_ARRAY	

COM VARIANT to MATLAB Conversion Rules

VARIANT Type	MATLAB Data Type (Scalar or Array Data)	Comments
VT_EMPTY	N/A	Empty array created.
VT_I1	int8	
VT_UI1	uint8	

COM VARIANT to MATLAB Conversion Rules (Continued)

VARIANT Type	MATLAB Data Type (Scalar or Array Data)	Comments
VT_I2	int16	
VT_UI2	uint16	
VT_I4	int32	
VT_UI4	uint32	
VT_R4	single	
VT_R8	double	
VT_CY	double	
VT_BSTR	char	A VARIANT of type VT_BSTR converts to a 1-by-L MATLAB char array, where L = the length of the string to be converted. A VARIANT of type VT_BSTR|VT_ARRAY converts to a MATLAB cell array of 1-by-L char arrays.
VT_ERROR	int32	
VT_DATE	double	VARIANT dates are stored as doubles starting at midnight Dec. 31, 1899. MATLAB dates are stored as doubles starting at 0/0/00 00:00:00. Therefore, a VARIANT date of 0.0 maps to a MATLAB numeric date of 693960.0. VARIANT dates are converted to MATLAB double types and incremented by 693960.0. VARIANT dates can be optionally converted to strings. See "Data Conversion Flags" on page

COM VARIANT to MATLAB Conversion Rules (Continued)

VARIANT Type	MATLAB Data Type (Scalar or Array Data)	Comments
		12-20 for more information on type coercion.
VT_INT	int32	
VT_UINT	uint32	
VT_DECIMAL	double	
VT_BOOL	logical	
VT_DISPATCH	*Varies*	IDispatch* pointers are treated within the context of what they point to. Objects must be supported types with known data extraction and conversion rules, or expose a generic Value property that points to a single VARIANT type. Data extracted from an object is converted based upon the rules for the particular VARIANT obtained. Currently, support exists for Excel Range objects as well as .NET Builder types MWStruct, MWComplex, MWSparse, and MWArg. See “Utility Library Classes” on page 13-3“Utility Library Classes” on page 13-3 for information on .NET Builder types to use with COM components.

COM VARIANT to MATLAB Conversion Rules (Continued)

VARIANT Type	MATLAB Data Type (Scalar or Array Data)	Comments
anything|VT_BYREF	*Varies*	Pointers to any of the basic types are processed according to the rules for what they point to. The resulting MATLAB array contains a deep copy of the values.
anything|VT_ARRAY	*Varies*	Multidimensional VARIANT arrays convert to multidimensional MATLAB arrays, each element converted according to the rules for the basic types. Multidimensional VARIANT arrays of type VT_VARIANT|VT_ARRAY convert to multidimensional cell arrays, each cell converted according to the rules for that specific type.

Array Formatting Flags

.NET Builder components have flags that control how array data is formatted in both directions. Generally, you should develop client code that matches the intended inputs and outputs of the MATLAB functions with the corresponding methods on the compiled COM objects, in accordance with the rules listed in MATLAB to COM VARIANT Conversion Rules on page 12-11 and COM VARIANT to MATLAB Conversion Rules on page 12-15. In some cases this is not possible, for example, when existing MATLAB code is used in conjunction with a third-party product like Excel.

The following table shows the array formatting flags.

Array Formatting Flags

Flag	Description
`InputArrayFormat`	Defines the array formatting rule used on input arrays. An input array is a `VARIANT` array, created by the client, sent as an input parameter to a method call on a compiled COM object. Valid values for this flag are `mwArrayFormatAsIs`, `mwArrayFormatMatrix`, and `mwArrayFormatCell`. `mwArrayFormatAsIs` passes the array unchanged. `mwArrayFormatMatrix` (default) formats all arrays as matrices. When the input `VARIANT` is of type `VT_ARRAY|` *`type`*, where *`type`* is any numeric type, this flag has no effect. When the input `VARIANT` is of type `VT_VARIANT|VT_ARRAY`, `VARIANT`s in the array are examined. If they are single-valued and homogeneous in type, a MATLAB matrix of the appropriate type is produced instead of a cell array. `mwArrayFormatCell` interprets all arrays as MATLAB cell arrays.
`InputArrayIndFlag`	Sets the input array indirection level used with the `InputArrayFormat` flag (applicable only to nested arrays, i.e., `VARIANT` arrays of `VARIANT`s, which themselves are arrays). The default value for this flag is zero, which applies the `InputArrayFormat` flag to the outermost array. When this flag is greater than zero, e.g., equal to N, the formatting rule attempts to apply itself to the Nth level of nesting.
`OutputArrayFormat`	Defines the array formatting rule used on output arrays. An output array is a MATLAB array, created by the compiled COM object, sent as an output parameter from a method call to the client. The values for this flag, `mwArrayFormatAsIs`, `mwArrayFormatMatrix`, and `mwArrayFormatCell`, cause the same behavior as the corresponding `InputArrayFormat` flag values.

Array Formatting Flags (Continued)

Flag	Description
`OutputArrayIndFlag`	(Applies to nested cell arrays only.) Output array indirection level used with the `OutputArrayFormat` flag. This flag works exactly like `InputArrayIndFlag`.
`AutoResizeOutput`	(Applies to Excel ranges only.) When the target output from a method call is a range of cells in an Excel worksheet and the output array size and shape is not known at the time of the call, set this flag to `True` to resize each Excel range to fit the output array.
`TransposeOutput`	Set this flag to `True` to transpose the output arguments. Useful when calling a .NET Builder component from Excel where the MATLAB function returns outputs as row vectors, and you want the data in columns.

Data Conversion Flags

.NET Builder components contain flags to control the conversion of certain `VARIANT` types to MATLAB types. These flags are as follows:

- "CoerceNumericToType" on page 12-20
- "InputDateFormat" on page 12-21
- "OutputAsDate As Boolean" on page 12-21
- "DateBias As Long" on page 12-21

CoerceNumericToType

This flag tells the data converter to convert all numeric `VARIANT` data to one specific MATLAB type. `VARIANT` type codes affected by this flag are `VT_I1`, `VT_UI1`, `VT_I2`, `VT_UI2`, `VT_I4`, `VT_UI4`, `VT_R4`, `VT_R8`, `VT_CY`, `VT_DECIMAL`, `VT_INT`, `VT_UINT`, `VT_ERROR`, `VT_BOOL`, and `VT_DATE`. Valid values for this flag are `mwTypeDefault`, `mwTypeChar`, `mwTypeDouble`, `mwTypeSingle`, `mwTypeLogical`, `mwTypeInt8`, `mwTypeUint8`, `mwTypeInt16`, `mwTypeUint16`, `mwTypeInt32`, and `mwTypeUint32`.

The default for this flag, `mwTypeDefault`, converts numeric data according to the rules listed in "Data Conversion Rules" on page 12-8.

InputDateFormat

This flag tells the data converter how to convert `VARIANT` dates to MATLAB dates. Valid values for this flag are `mwDateFormatNumeric` (default) and `mwDateFormatString`. The default converts `VARIANT` dates according to the rule listed in VARIANT Type Codes Supported on page 12-9 . The `mwDateFormatString` flag converts a `VARIANT` date to its string representation. This flag only affects `VARIANT` type code `VT_DATE`.

OutputAsDate As Boolean

This flag instructs the data converter to process an output argument as a date. By default, numeric dates that are output parameters from compiled MATLAB functions are passed as `Doubles` that need to be decremented by the COM date bias (693960) as well as coerced to COM dates. Set this flag to `True` to convert all output values of type `Double`.

DateBias As Long

This flag sets the date bias for performing COM to MATLAB numeric date conversions. The default value of this property is 693960, which represents the difference between the COM `Date` type and MATLAB numeric dates. This flag allows existing MATLAB code that already performs the increment of numeric dates by 693960 to be used unchanged with .NET Builder components. To process dates with such code, set this property to `0`.

Calling Conventions

When you use encapsulated M-functions in your code, you might need to understand some or all of the following aspects of MATLAB Builder for .NET processes.

- “Producing a COM Class” on page 12-22
- “IDL Mapping” on page 12-23
- “Visual Basic Mapping” on page 12-24

Producing a COM Class

Producing a COM class requires the generation of

- A class definition file in Interface Description Language (IDL)
- One or more associated C++ class definition/implementation files

.NET Builder automatically produces the necessary IDL and C/C++ code to build each COM class in the component. This process is generally transparent to you when you use .NET Builder to generate a COM component, and to users of the COM component when they program with it.

For information about IDL and C++ coding rules for building COM objects and for mappings to other languages, see articles in the MSDN Library.

The following table shows the mapping of a generic M-function to IDL code and to Visual Basic.

<table>
<tr><th>Code</th><th>Sample</th></tr>
<tr><td>Generic M-Code</td><td><pre>function [Y1, Y2, ..., varargout] = foo(X1, X2, ..., varargin)</pre></td></tr>
<tr><td>IDL Code</td><td><pre>HRESULT foo([in] long nargout,
            [in,out] VARIANT* Y1,
            [in,out] VARIANT* Y2,
            .
            .
            [in,out] VARIANT* varargout,
            [in] VARIANT X1,
            [in] VARIANT X2,
            .
            .
            [in] VARIANT varargin);</pre></td></tr>
<tr><td>Visual Basic Code</td><td><pre>Sub foo(nargout As Long, _
        Y1 As Variant, _
        Y2 As Variant, _
        .
        .
        varargout As Variant, _
        X1 As Variant, _
        X2 As Varaint, _
        .
        .
        varargin As Variant)</pre></td></tr>
</table>

IDL Mapping

The IDL function definition is generated by producing a function with the same name as the original M-function and an argument list containing all inputs and outputs of the original plus one additional parameter, `nargout`.

When present, the `nargout` parameter is an `[in]` parameter of type `long`. It is always the first argument in the list. This parameter allows correct passage of the MATLAB `nargout` parameter to the compiled M-code. The `nargout`

parameter is not produced if you encapsulate an M-function containing no outputs.

Following the `nargout` parameter, the outputs are listed in the order they appear on the left side of the MATLAB function, and are tagged as `[in,out]`, meaning that they are passed in both directions.

The function inputs are listed next, appearing in the same order as they do on the right side of the original function. All inputs are tagged as `[in]` parameters.

When present, the optional `varargin`/`varargout` parameters are always listed as the last input parameters and the last output parameters. All parameters other than `nargout` are passed as COM `VARIANT` types. "Data Conversion Rules" on page 12-8 lists the rules for conversion between MATLAB arrays and COM `VARIANT`s.

Visual Basic Mapping

Visual Basic provides native support for COM `Variants` with the `Variant` type, as well as implicit conversions for all Visual Basic basic types to and from `Variants`. In general, arrays/scalars of any Visual Basic basic type, as well as arrays/scalars of Variant types, can be passed as arguments.

.NET Builder components also provide direct support for the Excel `Range` object, used by Visual Basic for Applications to represent a range of cells in an Excel worksheet.

See the Visual Basic for Applications documentation included with Microsoft Excel for more information on Visual Basic data types.

See the MSDN Library for more information about Visual Basic and about Excel `Range` manipulation.

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Utility Library for COM Components

Referencing the Utility Classes (p. 13-2)	Referencing the classes in your programming environment
Utility Library Classes (p. 13-3)	Describes the classes provided in the Utility Library.
Enumerations (p. 13-31)	Describes the three provided sets of constants.

Referencing the Utility Classes

This section describes the `MWComUtil` Library. This library is freely distributable and includes several functions used in array processing, as well as type definitions used in data conversion. This library is contained in the file `mwcomutil.dll`. It must be registered once on each machine that uses COM components created by MATLAB Builder for .NET.

Register the `MWComUtil` library at the DOS command prompt with the command

```
mwregsvr mwcomutil.dll
```

The `MWComUtil` library includes seven classes (see “Utility Library Classes” on page 13-3) and three enumerated types (see “Enumerations” on page 13-31). Before using these types, you must make explicit references to the `MWComUtil` type libraries in the Visual Basic IDE. To do this select **Tools>References** from the main menu of the VB editor. The References dialog box appears with a scrollable list of available type libraries. From this list select **MWComUtil 1.0 Type Library** and click **OK**.

Utility Library Classes

The Utility Library provides several classes:

- "Class MWUtil" on page 13-3
- "Class MWFlags" on page 13-10
- "Class MWStruct" on page 13-16
- "Class MWField" on page 13-23
- "Class MWComplex" on page 13-24
- "Class MWSparse" on page 13-26
- "Class MWArg" on page 13-29

Class MWUtil

The `MWUtil` class contains a set of static utility methods used in array processing and application initialization. This class is implemented internally as a singleton (only one global instance of this class per instance of Excel). It is most efficient to declare one variable of this type in global scope within each module that uses it. The methods of `MWUtil` are

- "Sub MWInitApplication(pApp As Object)" on page 13-3
- "Sub MWPack(pVarArg, [Var0], [Var1], ... ,[Var31])" on page 13-5
- "Sub MWUnpack(VarArg, [nStartAt As Long], [bAutoResize As Boolean = False], [pVar0], [pVar1], ..., [pVar31])" on page 13-6
- "Sub MWDate2VariantDate(pVar)" on page 13-8

The function prototypes use Visual Basic syntax.

Sub MWInitApplication(pApp As Object)

Initializes the library with the current instance of Excel.

Parameters.

Argument	Type	Description
pApp	Object	A valid reference to the current Excel application

Return Value. None.

Remarks. This function must be called once for each session of Excel that uses COM components created by .NET Builder. An error is generated if a method call is made to a member class of any .NET Builder COM component, and the library has not been initialized.

Example. This Visual Basic sample initializes the `MWComUtil` library with the current instance of Excel. A global variable of type `Object` named `MCLUtil` holds an instance of the `MWUtil` class, and another global variable of type `Boolean` named `bModuleInitialized` stores the status of the initialization process. The private subroutine `InitModule()` creates an instance of the `MWComUtil` class and calls the `MWInitApplication` method with an argument of `Application`. Once this function succeeds, all subsequent calls exit without recreating the object.

```
Dim MCLUtil As Object
Dim bModuleInitialized As Boolean

Private Sub InitModule()
    If Not bModuleInitialized Then
        On Error GoTo Handle_Error
        If MCLUtil Is Nothing Then
            Set MCLUtil = CreateObject("MWComUtil.MWUtil")
        End If
        Call MCLUtil.MWInitApplication(Application)
        bModuleInitialized = True
        Exit Sub
Handle_Error:
        bModuleInitialized = False
    End If
End Sub
```

Sub MWPack(pVarArg, [Var0], [Var1], ... ,[Var31])

Packs a variable length list of `Variant` arguments into a single `Variant` array. This function is typically used for creating a `varargin` cell from a list of separate inputs. Each input in the list is added to the array only if it is nonempty and nonmissing. (In Visual Basic, a missing parameter is denoted by a `Variant` type of `vbError` with a value of `&H80020004`.)

Parameters.

Argument	Type	Description
`pVarArg`	`Variant`	Receives the resulting array
`[Var0], [Var1], ...`	`Variant`	Optional list of `Variants` to pack into the array. From 0 to 32 arguments can be passed.

Return Value. None.

Remarks. This function always frees the contents of `pVarArg` before processing the list.

Example. This example uses `MWPack` in a formula function to produce a `varargin` cell to pass as an input parameter to a method compiled from a MATLAB function with the signature

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

The function returns the sum of the elements in `varargin`. Assume that this function is a method of a class named `myclass` that is included in a component named `mycomponent` with a version of 1.0. The Visual Basic function allows up to 10 inputs, and returns the result `y`. If an error occurs, the function returns the error string. This function assumes that `MWInitApplication` has been previously called.

```
Function mysum(Optional V0 As Variant, _
               Optional V1 As Variant, _
               Optional V2 As Variant, _
               Optional V3 As Variant, _
               Optional V4 As Variant, _
               Optional V5 As Variant, _
               Optional V6 As Variant, _
               Optional V7 As Variant, _
               Optional V8 As Variant, _
               Optional V9 As Variant) As Variant
Dim y As Variant
Dim varargin As Variant
Dim aClass As Object
Dim aUtil As Object

    On Error Goto Handle_Error
    Set aClass = CreateObject("mycomponent.myclass.1_0")
    Set aUtil = CreateObject("MWComUtil.MWUtil")
    Call aUtil.MWPack(varargin,V0,V1,V2,V3,V4,V5,V6,V7,V8,V9)
    Call aClass.mysum(1, y, varargin)
    mysum = y
    Exit Function
Handle_Error:
    mysum = Err.Description
End Function
```

Sub MWUnpack(VarArg, [nStartAt As Long], [bAutoResize As Boolean = False], [pVar0], [pVar1], ..., [pVar31])

Unpacks an array of `Variants` into individual `Variant` arguments. This function provides the reverse functionality of `MWPack` and is typically used to process a `varargout` cell into individual `Variants`.

Parameters.

Argument	Type	Description
VarArg	Variant	Input array of Variants to be processed
nStartAt	Long	Optional starting index (zero-based) in the array to begin processing. Default = 0.
bAutoResize	Boolean	Optional auto-resize flag. If this flag is True, any Excel range output arguments are resized to fit the dimensions of the Variant to be copied. The resizing process is applied relative to the upper left corner of the supplied range. Default = False.
[pVar0],[pVar1], ...	Variant	Optional list of Variants to receive the array items contained in VarArg. From 0 to 32 arguments can be passed.

Return Value. None.

Remarks. This function can process a `Variant` array in one single call or through multiple calls using the `nStartAt` parameter.

Example. This example uses `MWUnpack` to process a `varargout` cell into several Excel ranges, while auto-resizing each range. The `varargout` parameter is supplied from a method that has been compiled from the MATLAB function.

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

This function produces a sequence of nargout random column vectors, with the length of the ith vector equal to i. Assume that this function is included in a class named myclass that is included in a component named mycomponent with a version of 1.0. The Visual Basic subroutine takes no arguments and places the results into Excel columns starting at A1, B1, C1, and D1. If an error occurs, a message box displays the error text. This function assumes that MWInitApplication has been previously called.

```
Sub GenVectors()
    Dim aClass As Object
    Dim aUtil As Object
    Dim v As Variant
    Dim R1 As Range
    Dim R2 As Range
    Dim R3 As Range
    Dim R4 As Range

    On Error GoTo Handle_Error
    Set aClass = CreateObject("mycomponent.myclass.1_0")
    Set aUtil = CreateObject("MWComUtil.MWUtil")
    Set R1 = Range("A1")
    Set R2 = Range("B1")
    Set R3 = Range("C1")
    Set R4 = Range("D1")
    Call aClass.randvectors(4, v)
    Call aUtil.MWUnpack(v,0,True,R1,R2,R3,R4)
    Exit Sub
Handle_Error:
    MsgBox (Err.Description)
End Sub
```

Sub MWDate2VariantDate(pVar)

Converts output dates from MATLAB to Variant dates.

Parameters.

Argument	Type	Description
pVar	Variant	Variant to be converted

Return Value. None.

Remarks. MATLAB handles dates as double-precision floating-point numbers with 0.0 representing 0/0/00 00:00:00. By default, numeric dates that are output parameters from compiled MATLAB functions are passed as Doubles that need to be decremented by the COM date bias as well as coerced to COM dates. The MWDate2VariantDate method performs this transformation and additionally converts dates in string form to COM date types.

Example. This example uses MWDate2VariantDate to process numeric dates returned from a method compiled from the following MATLAB function.

```
function x = getdates(n, inc)
    y = now;
    for i=1:n
        x(i,1) = y + (i-1)*inc;
    end
```

This function produces an n-length column vector of numeric values representing dates starting from the current date and time with each element incremented by inc days. Assume that this function is included in a class named myclass that is included in a component named mycomponent with a version of 1.0. The subroutine takes an Excel range and a Double as inputs and places the generated dates into the supplied range. If an error occurs, a message box displays the error text. This function assumes that MWInitApplication has been previously called.

```
Sub GenDates(R As Range, inc As Double)
    Dim aClass As Object
    Dim aUtil As Object

    On Error GoTo Handle_Error
    Set aClass = CreateObject("mycomponent.myclass.1_0")
```

```
    Set aUtil = CreateObject("MWComUtil.MWUtil")
    Call aClass.getdates(1, R, R.Rows.Count, inc)
    Call aUtil.MWDate2VariantDate(R)
    Exit Sub
Handle_Error:
    MsgBox (Err.Description)
End Sub
```

Class MWFlags

The MWFlags class contains a set of array formatting and data conversion flags (See "Data Conversion Rules" on page 12-8 for more information on conversion between MATLAB and COM Automation types). All .NET Builder COM components contain a reference to an MWFlags object that can modify data conversion rules at the object level. This class contains these properties:

- "Property ArrayFormatFlags As MWArrayFormatFlags" on page 13-10
- "Property DataConversionFlags As MWDataConversionFlags" on page 13-13
- "Sub Clone(ppFlags As MWFlags)" on page 13-15

Property ArrayFormatFlags As MWArrayFormatFlags

The ArrayFormatFlags property controls array formatting (as a matrix or a cell array) and the application of these rules to nested arrays. The MWArrayFormatFlags class is a noncreatable class accessed through an MWFlags class instance. This class contains six properties:

- "Property InputArrayFormat As mwArrayFormat" on page 13-11
- "Property InputArrayIndFlag As Long" on page 13-11
- "Property OutputArrayFormat As mwArrayFormat" on page 13-12
- "Property OutputArrayIndFlag As Long" on page 13-12
- "Property AutoResizeOutput As Boolean" on page 13-13
- "Property TransposeOutput As Boolean" on page 13-13

Property InputArrayFormat As mwArrayFormat. This property of type mwArrayFormat controls the formatting of arrays passed as input parameters to .NET Builder class methods. The default value is mwArrayFormatMatrix. The behaviors indicated by this flag are listed in the next table.

Array Formatting Rules for Input Arrays

Value	Behavior
mwArrayFormatAsIs	Converts arrays according to the default conversion rules listed in MATLAB to COM VARIANT Conversion Rules on page 12-11.
mwArrayFormatCell	Coerces all arrays into cell arrays. Input scalar or numeric array arguments are converted to cell arrays with each cell containing a scalar value for the respective index.
mwArrayFormatMatrix	Coerces all arrays into matrices. When an input argument is encountered that is an array of Variants (the default behavior is to convert it to a cell array), the data converter converts this array to a matrix if each Variant is single valued, and all elements are homogeneous and of a numeric type. If this conversion is not possible, creates a cell array.

Property InputArrayIndFlag As Long. This property governs the level at which to apply the rule set by the InputArrayFormat property for nested arrays (an array of Variants is passed and each element of the array is an array itself). It is not necessary to modify this flag for varargin parameters. The data conversion code automatically increments the value of this flag by 1 for varargin cells, thus applying the InputArrayFormat flag to each cell of a varargin parameter. The default value is 0.

Property OutputArrayFormat As mwArrayFormat. This property of type `mwArrayFormat` controls the formatting of arrays passed as output parameters to .NET Builder class methods. The default value is `mwArrayFormatAsIs`. The behaviors indicated by this flag are listed in the next table.

Array Formatting Rules for Output Arrays

Value	Behavior
`mwArrayFormatAsIs`	Converts arrays according to the default conversion rules listed in MATLAB to COM VARIANT Conversion Rules on page 12-11.
`mwArrayFormatMatrix`	Coerces all arrays into matrices. When an output cell array argument is encountered (the default behavior converts it to an array of `Variants`), the data converter converts this array to a `Variant` that contains a simple numeric array if each cell is single valued, and all elements are homogeneous and of a numeric type. If this conversion is not possible, an array of `Variants` is created.
`mwArrayFormatCell`	Coerces all output arrays into arrays of `Variants`. Output scalar or numeric array arguments are converted to arrays of `Variants`, each `Variant` containing a scalar value for the respective index.

Property OutputArrayIndFlag As Long. This property is similar to the `InputArrayIndFalg` property, as it governs the level at which to apply the rule set by the `OutputArrayFormat` property for nested arrays. As with the input case, this flag is automatically incremented by 1 for a `varargout` parameter. The default value of this flag is `0`.

Property AutoResizeOutput As Boolean. This flag applies to Excel ranges only. When the target output from a method call is a range of cells in an Excel worksheet, and the output array size and shape is not known at the time of the call, setting this flag to `True` instructs the data conversion code to resize each Excel range to fit the output array. Resizing is applied relative to the upper left corner of each supplied range. The default value for this flag is `False`.

Property TransposeOutput As Boolean. Setting this flag to `True` transposes the output arguments. This flag is useful when processing an output parameter from a method call on a COM component, where the MATLAB function returns outputs as row vectors, and you desire to place the data into columns. The default value for this flag is `False`.

Property DataConversionFlags As MWDataConversionFlags

The `DataConversionFlags` property controls how input variables are processed when type coercion is needed. The `MWDataConversionFlags` class is a noncreatable class accessed through an `MWFlags` class instance. This class contains these properties:

- "Property CoerceNumericToType As mwDataType" on page 13-13
- "Property InputDateFormat As mwDateFormat" on page 13-14
- "Example" on page 13-14
- "PropertyOutputAsDate As Boolean" on page 13-15
- "PropertyDateBias As Long" on page 13-15

Property CoerceNumericToType As mwDataType. This property converts all numeric input arguments to one specific MATLAB type. This flag is useful is when variables maintained within the Visual Basic code are different types, e.g., `Long`, `Integer`, etc., and all variables passed to the compiled MATLAB code must be doubles. The default value for this property is `mwTypeDefault`, which uses the default rules in COM VARIANT to MATLAB Conversion Rules on page 12-15COM VARIANT to MATLAB Conversion Rules on page 12-15.

Property InputDateFormat As mwDateFormat. This property converts dates passed as input parameters to method calls on .NET Builder classes. The default value is `mwDateFormatNumeric`. The behaviors indicated by this flag are shown in the following table.

Conversion Rules for Input Dates

Value	Behavior
`mwDateFormatNumeric`	Convert dates to numeric values as indicated by the rule listed in COM VARIANT to MATLAB Conversion Rules on page 12-15.
`mwDateFormatString`	Convert input dates to strings.

Example. This example uses data conversion flags to reshape the output from a method compiled from a MATLAB function that produces an output vector of unknown length.

```
function p = myprimes(n)
if length(n)~=1, error('N must be a scalar'); end
if n < 2, p = zeros(1,0); return, end
p = 1:2:n;
q = length(p);
p(1) = 2;
for k = 3:2:sqrt(n)
    if p((k+1)/2)
        p(((k*k+1)/2):k:q) = 0;
    end
end
p = (p(p>0));
```

This function produces a row vector of all the prime numbers between 0 and `n`. Assume that this function is included in a class named `myclass` that is included in a component named `mycomponent` with a version of 1.0. The subroutine takes an Excel range and a `Double` as inputs, and places the generated prime numbers into the supplied range. The MATLAB function produces a row vector, although you want the output in column format. It also produces an unknown number of outputs, and you do not want to truncate any output. To handle these issues, set the `TransposeOutput` flag and the

AutoResizeOutput flag to True. In previous examples, the Visual Basic CreateObject function creates the necessary classes. This example uses an explicit type declaration for the aClass variable. As with previous examples, this function assumes that MWInitApplication has been previously called.

```
Sub GenPrimes(R As Range, n As Double)
    Dim aClass As mycomponent.myclass

    On Error GoTo Handle_Error
    Set aClass = New mycomponent.myclass
    aClass.MWFlags.ArrayFormatFlags.AutoResizeOutput = True
    aClass.MWFlags.ArrayFormatFlags.TransposeOutput = True
    Call aClass.myprimes(1, R, n)
    Exit Sub
Handle_Error:
    MsgBox (Err.Description)
End Sub
```

PropertyOutputAsDate As Boolean. This property processes an output argument as a date. By default, numeric dates that are output parameters from compiled MATLAB functions are passed as Doubles that need to be decremented by the COM date bias (693960) as well as coerced to COM dates. Set this flag to True to convert all output values of type Double.

PropertyDateBias As Long. This property sets the date bias for performing COM to MATLAB numeric date conversions. The default value of this property is 693960, representing the difference between the COM Date type and MATLAB numeric dates. This flag allows existing MATLAB code that already performs the increment of numeric dates by 693960 to be used unchanged with COM components created by .NET Builder. To process dates with such code, set this property to 0.

Sub Clone(ppFlags As MWFlags)

Creates a copy of an MWFlags object.

Parameters.

Argument	Type	Description
ppFlags	MWFlags	Reference to an uninitialized MWFlags object that receives the copy

Return Value. None

Remarks. Clone allocates a new MWFlags object and creates a deep copy of the object's contents. Call this function when a separate object is required instead of a shared copy of an existing object reference.

Class MWStruct

The MWStruct class passes or receives a Struct type to or from a compiled class method. This class contains seven properties/methods:

- "Sub Initialize([varDims], [varFieldNames])" on page 13-16
- "Property Item([i0], [i1], ..., [i31]) As MWField" on page 13-18
- "Property NumberOfFields As Long" on page 13-21
- "Property NumberOfDims As Long" on page 13-21
- "Property Dims As Variant" on page 13-21
- "Property FieldNames As Variant" on page 13-21
- "Sub Clone(ppStruct As MWStruct)" on page 13-22

Sub Initialize([varDims], [varFieldNames])

This method allocates a structure array with a specified number and size of dimensions and a specified list of field names.

Parameters.

Argument	Type	Description
varDims	Variant	Optional array of dimensions
varFieldNames	Variant	Optional array of field names

Return Value. None.

Remarks. When created, an `MWStruct` object has a dimensionality of 1-by-1 and no fields. The `Initialize` method dimensions the array and adds a set of named fields to each element. Each time you call `Initialize` on the same object, it is redimensioned. If you do not supply the `varDims` argument, the existing number and size of the array's dimensions unchanged. If you do not supply the `varFieldNames` argument, the existing list of fields is not changed. Calling `Initialize` with no arguments leaves the array unchanged.

Example. The following Visual Basic code illustrates use of the `Initialize` method to dimension struct arrays.

```
Sub foo ()
    Dim x As MWStruct
    Dim y As MWStruct

    On Error Goto Handle_Error
    'Create 1X1 struct arrays with no fields for x, and y
    Set x = new MWStruct
    Set y = new MWStruct

    'Initialize x to be 2X2 with fields "red", "green", and "blue"
    Call x.Initialize(Array(2,2), Array("red", "green", "blue"))
    'Initialize y to be 1X5 with fields "name" and "age"
    Call y.Initialize(5, Array("name", "age"))

    'Re-dimension x to be 3X3 with the same field names
    Call x.Initialize(Array(3,3))

    'Add a new field to y
```

```
    Call y.Initialize(, Array("name", "age", "salary"))

    Exit Sub
Handle_Error:
    MsgBox(Err.Description)
End Sub
```

Property Item([i0], [i1], ..., [i31]) As MWField

The `Item` property is the default property of the `MWStruct` class. This property is used to set/get the value of a field at a particular index in the structure array.

Parameters.

Argument	Type	Description
`i0,i1, ..., i31`	`Variant`	Optional index arguments. Between 0 and 32 index arguments can be entered. To reference an element of the array, specify all indexes as well as the field name.

Remarks. When accessing a named field through this property, you must supply all dimensions of the requested field as well as the field name. This property always returns a single field value, and generates a bad index error if you provide an invalid or incomplete index list. Index arguments have four basic formats:

- Field name only

  This format may be used only in the case of a 1-by-1 structure array and returns the named field's value. For example:

  ```
  x("red") = 0.2
  x("green") = 0.4
  x("blue") = 0.6
  ```

In this example, the name of the `Item` property was neglected. This is possible since the `Item` property is the default property of the `MWStruct` class. In this case the two statements are equivalent:

```
x.Item("red") = 0.2
x("red") = 0.2
```

- Single index and field name

This format accesses array elements through a single subscripting notation. A single numeric index `n` followed by the field name returns the named field on the `n`th array element, navigating the array linearly in column-major order. For example, consider a 2-by-2 array of structures with fields `"red"`, `"green"`, and `"blue"` stored in a variable `x`. These two statements are equivalent:

```
y = x(2, "red")
y = x(2, 1, "red")
```

- All indices and field name

This format accesses an array element of an multidimensional array by specifying `n` indices. These statements access all four of the elements of the array in the previous example:

```
For I From 1 To 2
       For J From 1 To 2
              r(I, J) = x(I, J, "red")
              g(I, J) = x(I, J, "green")
              b(I, J) = x(I, J, "blue")
       Next
Next
```

- Array of indices and field name

This format accesses an array element by passing an array of indices and a field name. The next example rewrites the previous example using an index array:

```
Dim Index(1 To 2) As Integer
```

```
For I From 1 To 2
       Index(1) = I
       For J From 1 To 2
              Index(2) = J
              r(I, J) = x(Index, "red")
              g(I, J) = x(Index, "green")
              b(I, J) = x(Index, "blue")
       Next
Next
```

With these four formats, the `Item` property provides a very flexible indexing mechanism for structure arrays. Also note:

- You can combine the last two indexing formats. Several index arguments supplied in either scalar or array format are concatenated to form one index set. The combining stops when the number of dimensions has been reached. For example:

  ```
  Dim Index1(1 To 2) As Integer
  Dim Index2(1 To 2) As Integer

  Index1(1) = 1
  Index1(2) = 1
  Index2(1) = 3
  Index2(2) = 2
  x(Index1, Index2, 2, "red") = 0.5
  ```

The last statement resolves to

```
x(1, 1, 3, 2, 2, "red") = 0.5
```

- The field name must be the last index in the list. The following statement produces an error:

  ```
  y = x("blue", 1, 2)
  ```

- Field names are case sensitive.

Property NumberOfFields As Long

The read-only `NumberOfFields` property returns the number of fields in the structure array.

Property NumberOfDims As Long

The read-only `NumberOfDims` property returns the number of dimensions in the struct array.

Property Dims As Variant

The read-only `Dims` property returns an array of length `NumberOfDims` that contains the size of each dimension of the struct array.

Property FieldNames As Variant

The read-only `FieldNames` property returns an array of length `NumberOfFields` that contains the field names of the elements of the structure array.

Example. The next Visual Basic code sample illustrates how to access a two-dimensional structure array's fields when the field names and dimension sizes are not known in advance.

```
Sub foo ()
      Dim x As MWStruct
      Dim Dims as Variant
      Dim FieldNames As Variant


      On Error Goto Handle_Error
      '
      '... Call a method that returns an MWStruct in x
      '
      Dims = x.Dims
      FieldNames = x.FieldNames
      For I From 1 To Dims(1)
            For J From 1 To Dims(2)
                  For K From 1 To x.NumberOfFields
                        y = x(I,J,FieldNames(K))
                        ' ... Do something with y
```

```
                  Next
            Next
      Next
Exit Sub
Handle_Error:
      MsgBox(Err.Description)
End Sub
```

Sub Clone(ppStruct As MWStruct)

Creates a copy of an MWStruct object.

Parameters.

Argument	Type	Description
ppStruct	MWStruct	Reference to an uninitialized MWStruct object to receive the copy

Return Value. None

Remarks. Clone allocates a new MWStruct object and creates a deep copy of the object's contents. Call this function when a separate object is required instead of a shared copy of an existing object reference.

Example. The following Visual Basic example illustrates the difference between assignment and Clone for MWStruct objects.

```
Sub foo ()
    Dim x1 As MWStruct
    Dim x2 As MWStruct
    Dim x3 As MWStruct

    On Error Goto Handle_Error
    Set x1 = new MWStruct
    x1("name") = "John Smith"
    x1("age") = 35
```

```
    'Set reference of x1 to x2
     Set x2 = x1
    'Create new object for x3 and copy contents of x1 into it
     Call x1.Clone(x3)
    'x2's "age" field is also modified 'x3's "age" field unchanged
     x1("age") = 50
         .
         .
         .
     Exit Sub
Handle_Error:
     MsgBox(Err.Description)
End Sub
```

Class MWField

The `MWField` class holds a single field reference in an `MWStruct` object. This class is noncreatable and contains four properties/methods:

- "Property Name As String" on page 13-23
- "Property Value As Variant" on page 13-23
- "Property MWFlags As MWFlags" on page 13-23
- "Sub Clone(ppField As MWField)" on page 13-24

Property Name As String

The name of the field (read only).

Property Value As Variant

Stores the field's value (read/write). The `Value` property is the default property of the `MWField` class. The value of a field can be any type that is coercible to a `Variant`, as well as object types.

Property MWFlags As MWFlags

Stores a reference to an `MWFlags` object. This property sets or gets the array formatting and data conversion flags for a particular field. Each field in a

structure has its own MWFlags property. This property overrides the value of any flags set on the object whose methods are called.

Sub Clone(ppField As MWField)

Creates a copy of an MWField object.

Parameters.

Argument	Type	Description
ppField	MWField	Reference to an uninitialized MWField object to receive the copy

Return Value. None.

Remarks. Clone allocates a new MWField object and creates a deep copy of the object's contents. Call this function when a separate object is required instead of a shared copy of an existing object reference.

Class MWComplex

The MWComplex class passes or receives a complex numeric array into or from a compiled class method. This class contains four properties/methods:

- "Property Real As Variant" on page 13-24
- "Property Imag As Variant" on page 13-25
- "Property MWFlags As MWFlags" on page 13-26
- "Sub Clone(ppComplex As MWComplex)" on page 13-26

Property Real As Variant

Stores the real part of a complex array (read/write). The Real property is the default property of the MWComplex class. The value of this property can be any type coercible to a Variant, as well as object types, with the restriction that the underlying array must resolve to a numeric matrix (no cell data allowed).

Valid Visual Basic numeric types for complex arrays include `Byte`, `Integer`, `Long`, `Single`, `Double`, `Currency`, and `Variant/vbDecimal`.

Property Imag As Variant

Stores the imaginary part of a complex array (read/write). The `Imag` property is optional and can be `Empty` for a pure real array. If the `Imag` property is nonempty and the size and type of the underlying array do not match the size and type of the `Real` property's array, an error results when the object is used in a method call.

Example. The following Visual Basic code creates a complex array with the following entries:

```
    x = [ 1+i 1+2i
           2+i 2+2i ]
Sub foo()
    Dim x As MWComplex
    Dim rval(1 To 2, 1 To 2) As Double
    Dim ival(1 To 2, 1 To 2) As Double

    On Error Goto Handle_Error
    For I = 1 To 2
        For J = 1 To 2
                rval(I,J) = I
                ival(I,J) = J
        Next
    Next
    Set x = new MWComplex
    x.Real = rval
    x.Imag = ival
        .
        .
        .
    Exit Sub
Handle_Error:
    MsgBox(Err.Description)
End Sub
```

Property MWFlags As MWFlags

Stores a reference to an MWFlags object. This property sets or gets the array formatting and data conversion flags for a particular complex array. Each MWComplex object has its own MWFlags property. This property overrides the value of any flags set on the object whose methods are called.

Sub Clone(ppComplex As MWComplex)

Creates a copy of an MWComplex object.

Parameters.

Argument	Type	Description
ppComplex	MWComplex	Reference to an uninitialized MWComplex object to receive the copy

Return Value. None

Remarks. Clone allocates a new MWComplex object and creates a deep copy of the object's contents. Call this function when a separate object is required instead of a shared copy of an existing object reference.

Class MWSparse

The MWSparse class passes or receives a two-dimensional sparse numeric array into or from a compiled class method. This class has seven properties/methods:

- "Property NumRows As Long" on page 13-27
- "Property NumColumns As Long" on page 13-27
- "Property RowIndex As Variant" on page 13-27
- "Property ColumnIndex As Variant" on page 13-27
- "Property Array As Variant" on page 13-27
- "Property MWFlags As MWFlags" on page 13-28
- "Sub Clone(ppSparse As MWSparse)" on page 13-28

Property NumRows As Long

Stores the row dimension for the array. The value of `NumRows` must be nonnegative. If the value is zero, the row index is taken from the maximum of the values in the `RowIndex` array.

Property NumColumns As Long

Stores the column dimension for the array. The value of `NumColumns` must be nonnegative. If the value is zero, the row index is taken from the maximum of the values in the `ColumnIndex` array.

Property RowIndex As Variant

Stores the array of row indices of the nonzero elements of the array. The value of this property can be any type coercible to a `Variant`, as well as object types, with the restriction that the underlying array must resolve to or be coercible to a numeric matrix of type `Long`. If the value of `NumRows` is nonzero and any row index is greater than `NumRows`, a bad-index error occurs. An error also results if the number of elements in the `RowIndex` array does not match the number of elements in the `Array` property's underlying array.

Property ColumnIndex As Variant

Stores the array of column indices of the nonzero elements of the array. The value of this property can be any type coercible to a `Variant`, as well as object types, with the restriction that the underlying array must resolve to or be coercible to a numeric matrix of type `Long`. If the value of `NumColumns` is nonzero and any column index is greater than `NumColumns`, a bad-index error occurs. An error also results if the number of elements in the `ColumnIndex` array does not match the number of elements in the `Array` property's underlying array.

Property Array As Variant

Stores the nonzero array values of the sparse array. The value of this property can be any type coercible to a `Variant`, as well as object types, with the restriction that the underlying array must resolve to or be coercible to a numeric matrix of type `Double` or `Boolean`.

Property MWFlags As MWFlags

Stores a reference to an MWFlags object. This property sets or gets the array formatting and data conversion flags for a particular sparse array. Each MWSparse object has its own MWFlags property. This property overrides the value of any flags set on the object whose methods are called.

Sub Clone(ppSparse As MWSparse)

Creates a copy of an MWSparse object.

Parameters.

Argument	Type	Description
ppSparse	MWSparse	Reference to an uninitialized MWSparse object to receive the copy

Return Value. None.

Remarks. Clone allocates a new MWSparse object and creates a deep copy of the object's contents. Call this function when a separate object is required instead of a shared copy of an existing object reference.

Example. The following Visual Basic sample creates a 5-by-5 tridiagonal sparse array with the following entries:

```
X = [ 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 ]

Sub foo()
    Dim x As MWSparse
    Dim rows(1 To 13) As Long
    Dim cols(1 To 13) As Long
    Dim vals(1 To 13) As Double
```

```
    Dim I As Long, K As Long

    On Error GoTo Handle_Error
    K = 1
    For I = 1 To 4
        rows(K) = I
        cols(K) = I + 1
        vals(K) = -1
        K = K + 1
        rows(K) = I
        cols(K) = I
        vals(K) = 2
        K = K + 1
        rows(K) = I + 1
        cols(K) = I
        vals(K) = -1
        K = K + 1
    Next
    rows(K) = 5
    cols(K) = 5
    vals(K) = 2
    Set x = New MWSparse
    x.NumRows = 5
    x.NumColumns = 5
    x.RowIndex = rows
    x.ColumnIndex = cols
    x.Array = vals
        .
        .
        .
    Exit Sub
Handle_Error:
    MsgBox (Err.Description)
End Sub
```

Class MWArg

The `MWArg` class passes a generic argument into a compiled class method. This class passes an argument for which the data conversion flags are changed for that one argument. This class has three properties/methods:

- "Property Value As Variant" on page 13-30
- "Property MWFlags As MWFlags" on page 13-30
- "Sub Clone(ppArg As MWArg)" on page 13-30

Property Value As Variant

The `Value` property stores the actual argument to pass. Any type that can be passed to a compiled method is valid for this property.

Property MWFlags As MWFlags

Stores a reference to an `MWFlags` object. This property sets or gets the array formatting and data conversion flags for a particular argument. Each `MWArg` object has its own `MWFlags` property. This property overrides the value of any flags set on the object whose methods are called.

Sub Clone(ppArg As MWArg)

Creates a copy of an `MWArg` object.

Parameters.

Argument	Type	Description
`ppArg`	`MWArg`	Reference to an uninitialized `MWArg` object to receive the copy

Return Value. None.

Remarks. Clone allocates a new `MWArg` object and creates a deep copy of the object's contents. Call this function when a separate object is required instead of a shared copy of an existing object reference.

Enumerations

The Utility Library provides three enumerations (sets of constants):

- "Enum mwArrayFormat" on page 13-31
- "Enum mwDataType" on page 13-31
- "Enum mwDateFormat" on page 13-32

Enum mwArrayFormat

The `mwArrayFormat` enumeration is a set of constants that denote an array formatting rule for data conversion.

mwArrayFormat Values

Constant	Numeric Value	Description
`mwArrayFormatAsIs`	0	Do not reformat the array.
`mwArrayFormatMatrix`	1	Format the array as a matrix.
`mwArrayFormatCell`	2	Format the array as a cell array.

Enum mwDataType

The `mwDataType` enumeration is a set of constants that denote a MATLAB numeric type.

mwDataType Values

Constant	Numeric Value	MATLAB Type
`mwTypeDefault`	0	`N/A`
`mwTypeLogical`	3	`logical`
`mwTypeChar`	4	`char`
`mwTypeDouble`	6	`double`

mwDataType Values (Continued)

Constant	Numeric Value	MATLAB Type
mwTypeSingle	7	single
mwTypeInt8	8	int8
mwTypeUint8	9	uint8
mwTypeInt16	10	int16
mwTypeUint16	11	uint16
mwTypeInt32	12	int32
mwTypeUint32	13	uint32

Enum mwDateFormat

The mwDateFormat enumeration is a set of constants that denote a formatting rule for dates.

mwDateFormat Values

Constant	Numeric Value	Description
mwDateFormatNumeric	0	Format dates as numeric values
mwDateFormatString	1	Format dates as strings

Examples

Use this list to find examples in the documentation.

Quick Start

"Magic Square Example" on page 1-10

Sample Applications (C#)

"Plot Example" on page 4-2
"Variable Arguments Example" on page 4-7
"Spectral Analysis Example" on page 4-13
"Matrix Math Example" on page 4-21

Sample Applications (Visual Basic .NET)

"Magic Square Example (Visual Basic)" on page 5-3
"Create Plot Example (Visual Basic)" on page 5-7
"Variable Arguments Example (Visual Basic)" on page 5-11
"Spectral Analysis Example (Visual Basic)" on page 5-15
"MatrixMath Example (Visual Basic)" on page 5-20

COM Components

"Calling a COM Object in a C++ Program" on page 10-12
"Creating and Using a varargin Array in Visual Basic Programs" on page 10-19
"Creating and Using varargout in Visual Basic Programs" on page 10-20
"Using Array Formatting Flags" on page 10-23
"Using Data Conversion Flags" on page 10-25
"Using MATLAB Global Variables in Visual Basic" on page 10-28
"Blocking Execution of a Console Application that Creates Figures" on page 10-31
"Magic Square Example" on page 11-2
"Creating an Excel Add-In: Spectral Analysis Example" on page 11-9
"Univariate Interpolation" on page 11-23

"Matrix Calculator" on page 11-31
"Curve Fitting" on page 11-42
"Bouncing Ball Simulation" on page 11-50

Glossary

assembly
Logical collection of one or more managed EXE or DLL files containing a .NET application's code and resources.

CLS
See Common Language Specification

Common Language Runtime (CLR)
Run-time environment provided by the .NET Framework, which runs the code and provides services that make the development process easier.

Common Language Specification (CLS)
A subset of language features supported by the **.NET common language runtime (CLR)**. CLS includes features common to several object-oriented programming languages, such as C#, VB.NET, and C++ with managed extensions. CLS-compliant components and tools are guaranteed to interoperate with other CLS-compliant components and tools.

component installer
The self-extracting executable created by the .NET Builder packaging process, which is used to deploy components created by .NET Builder.

.ctf files
Component Technology Files, which are the encrypted MATLAB functions compiled by .NET Builder.

data conversion classes
Provided by .NET Builder to handle passing data between MATLAB and other languages.

feval API
Interface generated by .NET Builder for a MATLAB function. Includes both input and output arguments in the argument list. Output arguments are specified first, followed by the input arguments.

finalization
Semiautomatic mechanism provided by the .NET Framework to help clean up **native resources** just before garbage collection of a managed object.

managed
Code written in a programming language that uses the Microsoft .NET Framework. The languages share a unified set of class libraries and can be encoded into an Intermediate Language (IL). A runtime-aware compiler compiles the IL into native executable code within a managed execution environment that ensures type safety, array bound and index checking, exception handling, and garbage collection.

marshal
To gather data from one or more applications and convert it to a format that is prescribed for a particular receiver or programming interface.

MATLAB Component Runtime (MCR)
Part of MATLAB Builder for .NET. Required to run MATLAB applications on machines that do not have the MATLAB desktop installed.

mxArray
The MATLAB language works with only a single object type: the MATLAB array. All MATLAB variables, including scalars, vectors, matrices, strings, cell arrays, structures, and objects are stored as MATLAB arrays. In C, the MATLAB array is declared to be of type `mxArray`. The `mxArray` structure contains, among other things: its type, its dimensions, the data associated with this array, the number of fields and field names (if a structure or object).

native code resources
Resources that exist outside the control of the **CLR**.

.NET Framework
.NET is a software architecture developed by Microsoft to build component-based applications. .NET components expose interfaces that allow other managed applications and components to access their encapsulated functions.

Pascal case

A convention for capitalizing identifier names. The first letter in the identifier and the first letter of each subsequent concatenated word is capitalized. For example: `MakeSquare`.

project

A feature of MATLAB Builder for .NET accessed via the Deployment Tool, which appears when you issue the `deploytool` command. A project specifies components and classes to be created and the functions to be encapsulated in them.

reflection

Programming technique supported by **CLR**. Used to dynamically create an instance of a type, bind the type to an existing object, or get the type from an existing object, and then invoke the type's methods or access its fields and properties.

single output API

Interface generated by .NET Builder for a MATLAB function when only a single output is required. Returns result as a single `MWArray` rather than an array of `MWArray`s.

standard API

Interface generated by .NET Builder for a MATLAB function. Specifies inputs within the argument list and outputs as an array of `MWArray` return values.

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