CHAPTER 1

The C# Language

- Basics of .NET
- Installing a C# development environment
- The C# runtime environment
- C# programming basics
- C# features

In its short history, the Microsoft .NET technology has quickly become a popular programming platform for developing applications for Microsoft Windows workstations and servers. Although most of the media attention has focused around the web application capabilities of .NET, there are many other features that are useful to Windows programmers.

One of those features is the new C# programming language, developed specifically for .NET. C# is becoming a widely used programming platform for programmers wanting to create both network-aware and stand-alone applications for Windows systems. The language provides many resources to help create robust Windows-based applications. Many programmers are migrating to the C# language to take advantage of these resources.

Before learning the basics of network programming in C#, it is important that you understand the C# programming environment, the fundamentals of .NET, and how to create and distribute C# applications. This chapter shows how to create a C# development environment on your system and how to ensure that C# applications you create will run on other Windows workstations and servers. Finally, I'll present a brief introduction to the C# language, along with some C# programming topics relevant to network programming. All together, the concepts presented in this chapter will help you get ready for C# network programming.

Basics of .NET

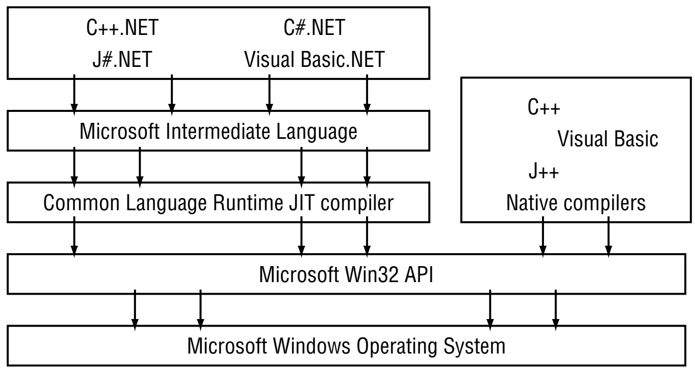
The .NET group of programming languages differs from previous versions of Windows programming languages in the way programs are created and run on the Windows systems. If you are not familiar with how C# programs operate, this section briefly describes the basics you should know to be able to deploy applications based on the .NET technologies.

Common Language Runtime (CLR)

The core of the Microsoft .NET technology is the *Common Language Runtime (CLR) environment*. This environment enables programmers to create programs using a multitude of programming languages and run them on any platform that supports the CLR. The idea of the CLR is to provide a middle layer of Application Program Interfaces (APIs) that operate between the low-level Windows Win32 API functions and the application program code. By providing a common middle layer, Microsoft has given a larger number of application languages access to core Windows technologies (such as network support).

The layout of how application programs run in the CLR environment is shown in Figure 1.1. High-level applications written in various .NET languages, such as Visual Basic .NET, Visual C++ .NET, Visual J# .NET, and of course Visual C# .NET, are compiled into a special intermediate language called *Microsoft Intermediate Language (MSIL)*. The MSIL code is interpreted by the CLR as the program runs; MSIL runs on the host operating system as a normal executable program. Of course, legacy programs that do not use the CLR can still directly access the low-level Windows Win32 APIs as before.

FIGURE 1.1: The Common Language Runtime (CLR) environment



This CLR model also pertains to other operating systems. Because the CLR is ported to other operating systems, .NET programs will be able to run without recompiling them on the new host systems. Currently, Microsoft supports the Shared Source Common Language Interface (CLI) project (nicknamed Rotor), which ports the CLR environment to the FreeBSD operating system. It is expected that the Rotor project will branch out to other operating systems as well. At the time of this writing you can get more information about Rotor at the following website:

```
http://msdn.microsoft.com/downloads/default.asp?URL=/downloads/sample.asp?url=
/msdn-files/027/001/901/msdncompositedoc.xml
```

For programs to run in the CLR, they must be compiled into the special MSIL format. The .NET C# compiler is used to convert C# language programs to MSIL code that runs in the CLR environment. The next section describes the MSIL code.

MSIL Code

When you compile a C# program, it produces an executable file. However, this executable file is different from the ones you may be used to seeing produced from other Windows compilers. Instead of a low-level assembly program that can run directly in Windows, this executable file contains two parts:

- A *stub* assembly language program to start the CLR compiler
- The MSIL code of the compiled application

The stub program starts the CLR just-in-time (JIT) compiler, which compiles the MSIL program code to native Win32 code that can be run on the system. Unlike native Windows applications, which interact directly with the low-level Win32 API system, .NET applications rely on the .NET Framework CLR to run. Running a .NET application on a system that does not have the .NET Framework installed will produce an error message like the one in Figure 1.2. The .NET Framework is crucial to any .NET application, whether it is running on a Windows workstation or server. Without it the MSIL code cannot run. Any Windows workstation or server expected to run .NET programs must have the .NET Framework installed.

FIGURE 1.2: Trying to run a .NET application without the .NET Framework

Microsoft is committed to ensuring the .NET Framework will be installed on all future versions of the Windows OS. However, older versions of Windows must have the .NET Framework manually installed. The following section includes instructions for installing the .NET Framework for a developer environment to allow you to create, compile, and run .NET applications.

Installing a C# Development Environment

Before you can begin programming in C#, you must have a C# development environment—a system for creating, compiling, and debugging C# programs. Unfortunately, one of the most stringent requirements for .NET application development is the designation of OS platform to use for development. Currently, .NET requires one of the following systems for full C# program development:

- Windows NT 4 Workstation or Server (with Service Pack 6a)
- Windows 2000 Professional or Server (with Service Pack 2)
- Windows XP Home Edition or Professional

Programmers without access to any of these systems will not be able to develop C# programs—but there is a solution to this, as will be explained later in the C# Runtime Environment section.

C# Development Options

Microsoft offers three development environments for C# developers. Each environment has its own set of pros and cons. This section describes these C# development environments and how they differ.

- Visual Studio .NET
- Visual C# .NET
- .NET Framework software development kit (SDK)

NOTE All of the example programs in this book can be compiled in any of the .NET development environments. To simplify things, this book's examples are shown using the .NET Framework command-line compiler. This ensures that anyone can use the examples, no matter which development environment you are using.

Visual Studio .NET

The Visual Studio .NET package is the flagship development product for Microsoft .NET. This Integrated Development Environment (IDE) offers many features to assist your Windows application programming tasks. Microsoft describes the Visual Studio package as "a rapid application development (RAD) tool, enabling programmers to quickly code and debug .NET applications." It includes a complete graphical environment for creating Windows forms, typing code, and debugging programs. In addition to containing a fancy development environment, Visual Studio also supports all the .NET programming languages—Visual Basic .NET, Visual C++ .NET, Visual J# .NET, and Visual C# .NET. If you are looking at developing with all of the .NET languages, the Visual Studio package is well worth the extra expense.

In Visual Studio .NET, applications can be created in a graphical environment using any of the four programming languages. The IDE provides separate windows for developing code and for visually laying out Window controls for the application, including text boxes, list boxes, buttons, and scrollbars. Visual Studio .NET offers an easy way to create, test, and debug .NET applications, whether they are stand-alone Windows applications or ASP.NET web pages.

There are several package levels for Visual Studio .NET, depending on your development requirements (and budget). Each package level includes progressively more development functionality, and also comes with a progressively higher price tag.

Visual C# .NET

If you are interested only in programming using the C# language, you do not have to buy the full Visual Studio .NET package. Instead, Microsoft offers the Visual C# .NET package, which has the same functionality of Visual Studio .NET but supports only the C# language. This is a much less expensive method of development for C# programmers. Similar to Visual Studio, the Visual C# package also comes in various package levels, from a bare-bones student version to a full-featured professional developer version. Before you choose this version, however, be aware that it does not include some of the advanced features, such as automatic database support, that are in Visual Studio .NET.

Both the Visual Studio and C# development options require that you purchase a commercial software development package from Microsoft. Both are excellent software development packages that can save you hours of time in creating Windows and debugging applications. However, many first-time and hobbyist programmers might find the cost of these IDE packages too great.

.NET Framework SDK

If you are looking for an inexpensive way to get started with C# programming, the .NET Framework SDK is the way to go. The SDK is available free from Microsoft and contains command-line tools for compiling and debugging .NET programs, including C#. This package allows you to get the feel for developing C# applications without investing in an expensive IDE development environment. You can obtain the .NET Framework SDK package by downloading the complete package via Microsoft's .NET Framework website, or by ordering a minimal-cost CD directly from Microsoft. (See the upcoming section for website information.)

If you are completely new to C#, you may want to start by downloading the .NET Framework SDK and giving it a try. It is often said that the best way to learn a programming language is to hand-code all your programs and suffer the consequences—I think this is especially true of network programming. As you progress in your C# programming skills, you can migrate to the Visual C# .NET package for creating Windows forms and debugging complex applications. To get you started, the following section describes how to download and install the .NET Framework SDK.

Downloading the .NET Framework SDK

At the time of this writing, the current version of the .NET Framework SDK is release 1. As mentioned, it can be downloaded free or you can purchase a CD from Microsoft. If you choose to download the package from Microsoft, there are two methods that can be used. Because the SDK is so large (131MB), you can either download it in one piece, or as ten smaller (13.1MB) packages that can be assembled after the download. Both methods require the same amount of data to be downloaded, but people with slower connections may want the convenience of downloading the individual pieces one at a time.

The .NET Framework website URL is currently `www.microsoft.com/netframework/`. As is common on the Web, this location may change by the time you read this. If so, just go to the Microsoft home page (`www.microsoft.com`) and look for the .NET stuff.

The .NET Framework site contains lots of information about the SDK, including a link to the separate software download page. The download page shows the various options for downloading the software. The single-file download is a file named `setup.exe`, which can be downloaded to your workstation or server for installation. If you select the multipart download option, you must download all of the split SDK files, along with the separate `setup.bat` file, to a temporary directory. After all of the files are downloaded, you must run the `setup.bat` file. This file creates the master `setup.exe` file from all of the SDK split files.

In either download scenario, the resulting file will be a `setup.exe` file. You must run this file to install the .NET Framework SDK package. The following section describes this process.

Installing the .NET Framework SDK

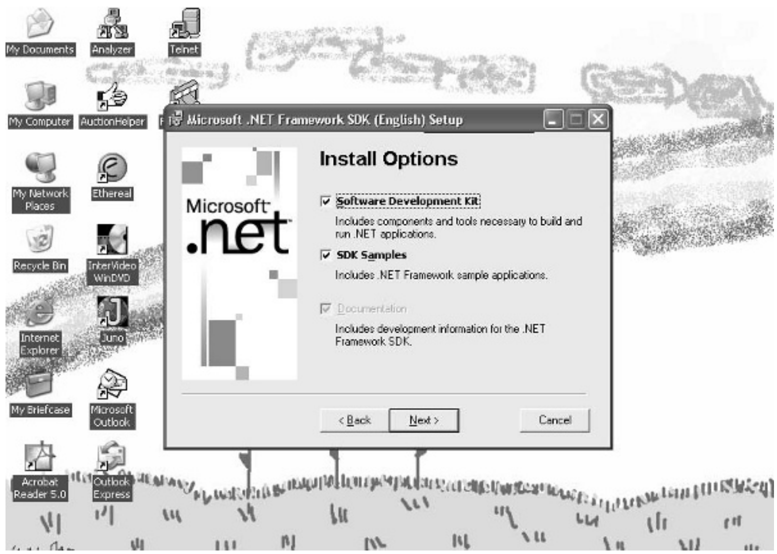
Once the `setup.exe` file is obtained, either by single download, multipart download, or CD, you can install the .NET Framework SDK. You start the installation by running the `setup.exe` file from a DOS command prompt, or by double-clicking it in Windows Explorer.

When the installation starts, a dialog box asks if you want to install the .NET Framework SDK. Click the Yes button to start the installation.

The .NET installation process first extracts the working installation files into a temporary directory, pointed to by the TEMP environment variable. This allows you to place the temporary working files on a drive other than the system drive (usually C:\) if you are tight on disk space. After the working files are extracted, the installation updates the Windows installer package on the workstation and then launches Windows installer with the .NET Framework installation.

After the opening screen and a license agreement screen, you are asked which components of the SDK package you want installed. This is shown in Figure 1.3.

FIGURE 1.3:
.NET Framework Install Options screen



If you are tight on disk space, you can prevent the SDK samples from being loaded on the workstation by deselecting the SDK Samples checkbox. After the Install Options screen, the program asks where to install the SDK components. This only applies to some of the components, as the DLLs and executable files used by the .NET Framework must be installed on the system drive (usually C:\). After you select the installation destination, the installation begins. When it's completed, you should be ready to compile and run C# programs.

TIP It"s a good idea to check out the Microsoft .NET Framework home page occasionally to see if new service packs are released, and then to install them as directed.

The C# Runtime Environment

The .NET Framework provides not only a development environment, but also a CLR environment for Windows workstations and servers that only run .NET programs. The .NET Framework contains lots of DLL files used to supply libraries to support .NET application programs. These libraries must be loaded on any workstation or server you want your .NET program to run on. However, you do not need to load the .NET Framework SDK on every machine that runs your program. As alluded to previously, Microsoft has a solution to this aggravation.

Microsoft has indicated that all future Windows operating systems will include the .NET Framework runtime (CLR) environment, starting with the Windows .NET Server release. This will ensure that .NET applications will run on the new OSes without your having to manually install any .NET Framework libraries. Unfortunately, this is not the case with older versions of Windows (98, Me, NT, 2000, and XP). The solution for these systems is manually installing a runtime version of the .NET Framework libraries.

The .NET Framework runtime version is a much smaller distribution than the SDK package. It includes only the files necessary to run .NET applications on the Windows workstation or server. The following section describes how to download and install the .NET Framework runtime files on older Windows platforms.

Downloading and Installing the C# Runtime Package

The C# runtime package is part of the .NET Framework Redistributable package. The Redistributable package contains runtime environments for all .NET languages. Similar to the SDK package, the Redistributable package can be obtained from the .NET Framework home page at `www.microsoft.com/netframework/`. Because this is a much smaller distribution, there is no multipart download option. The entire package must be downloaded as a single piece (about 20MB).

The download file, `dotnetredist.exe`, is actually a compressed file that must be uncompressed into a working directory. When you run the program, it will ask for a working directory to use. You can choose any location that has enough space (about 22MB). The extracted file is named `dotnetfx.exe`.

There is not much to installing the .NET Framework Redistributable package. After starting the `dotnetfx.exe` file, you're asked to confirm the installation, and then the files are installed. You don't have any choice as to locations for the Redistributable package files; they all go into default locations on the system drive.

Developing with the C# Runtime

Currently, the .NET Framework Redistributable package includes the C# compiler program, `csc.exe`. This allows developers who do not have workstations or servers running Windows NT 4, 2000, or XP to compile C# programs without installing the .NET Framework SDK. Any machine that supports the .NET Framework runtime can be used to compile C# applications using the `csc.exe` program. This includes Windows 98 and Me workstations. Though the compiler is included, none of the documentation or debugging programs are, so this is pretty much a bare-bones development environment.

If you want to compile C# programs from the Redistributable package, you must add the location of the `csc.exe` program to the PATH environment variable of your system. This differs depending on the system you are using.

- For Windows 98 and Me systems, you can add the PATH statement in the `autoexec.bat` file located in the `C:\` directory. There may already be an `autoexec.bat` file present, and it may already have a PATH statement in it. If so, you can append the `csc.exe` path to the existing PATH statement.
- For release 1 of the .NET Framework Redistributable package, `csc.exe` is located in the `C:\Windows\Microsoft.Net\Framework\v1.0.3705` directory. (Remember that on Windows 98 and Me, the Windows system directory is called `Windows`; on Windows NT and 2000 systems, it is `Winnt`.)

After rebooting the system you should be able to access the `csc.exe` compiler program from the command-line prompt, as in the following example:

```
C:\>csc
Microsoft (R) Visual C# .NET Compiler version 7.00.9466
for Microsoft (R) .NET Framework version 1.0.3705
Copyright (C) Microsoft Corporation 2001. All rights reserved.

fatal error CS2008: No inputs specified

C:\>
```

You are now ready to start programming using the C# language.

C# Programming Basics

Though it's considered a bare-bones development environment, the .NET Framework SDK contains quite a few tools that allow you to create, compile, and debug C# programs. This section describes some of the tools that are at your disposal.

Creating C# Programs

If you are using one of the Microsoft Visual products to develop your programs (Visual Studio .NET or Visual C# .NET), you have a complete program editing environment, including help files, graphical wizards, and command completion wizards. If you are using the .NET Framework SDK package, you are on your own for producing and compiling your C# code. Although this SDK's features pale in comparison to the fancy Visual packages, it is nonetheless just as valid a way to produce C# applications.

The first step to working with C# programs in the .NET Framework development environment is to associate the C# source code filename extension with a text editor. This will make editing programs much easier; you can just double-click a program from within the Windows Explorer program to begin editing. The type of editor you select is important. Choose one that allows you to save your source code files in text mode rather than a Microsoft Word `.doc` file or other word processing document, because the C# compiler must be able to interpret each line of code. If you do select a word processing package to edit your C# programs, make sure that you save all of the files in text format.

After you select an editor, associate the `.CS` file type to the editor application within the Windows Explorer: right-click a C# program, select the Open With option, and select the appropriate application from the list.

If you are new to C#, you may want to practice compiling and debugging C# programs. To do that, you must first have a sample program to work with. Listing 1.1 shows a simple program that demonstrates some basic C# programming principles.

Listing 1.1 SampleClass.cs program

```
class DataClass
{
    private int a;
    private int b;

    public DataClass(int x, int y)
    {
        a = x;
        b = y;
    }

    public int addem()
    {
        return a + b;
    }
}

class SampleClass
{
    static int sampleX;
    static int sampleY;

    public SampleClass()
    {
        DataClass sample = new DataClass(sampleX, sampleY);
        System.Console.WriteLine("The result is: {0}", sample.addem());
    }

    public static void Main(string[] argv)
    {
    if (argv.Length != 2)
```

```
            {
                System.Console.WriteLine("  Usage: SampleClass x y");
                return;
            }
            sampleX = System.Convert.ToInt16(argv[0]);
            sampleY = System.Convert.ToInt16(argv[1]);
            SampleClass starthere = new SampleClass();
        }
    }
```

The sample program contains two separate C# classes, DataClass and SampleClass. DataClass declares two private integers (that is, they are only accessible from the DataClass class), a constructor for the class, and a method that manipulates the data. The DataClass constructor defines what happens when DataClass is instantiated from a program:

```
public DataClass(int x, int y)
    {
        a = x;
        b = y;
    }
```

The default constructor requires two integers. The two integers are assigned to the internal private variables *a* and *b* defined in the class. The one method that is defined, addem, returns an integer value that is the addition of the two private variables:

```
public int addem()
    {
        return a + b;
    }
```

NOTE Once DataClass is defined in the program, other classes in the program can use it. In C#, unlike C++, you can use classes before they are defined without first declaring them. The SampleClass code could just as easily have been defined first, before the DataClass definition. The C# compiler will realize that the required class is located later in the program. You can even declare classes in separate files, as long as you include them on the command line when compiling. The compiler will only complain if declared classes are never found in any of the program files listed on the command line.

SampleClass contains two static integer variables, a constructor, and a Main() method, which instructs the C# compiler where to start execution of the program. The Main() method first checks to ensure that two command-line parameters have been entered, converts them to integer values, and assigns them to the two integer variables defined. It then creates an instance of SampleClass using the statement

```
SampleClass starthere = new SampleClass();
```

This forces the CLR to execute the SampleClass constructor to create a new instance of the class.

The `SampleClass` constructor code creates an instance of `DataClass`, passing the two integers to the `DataClass` class constructor. The `addem()` method is called from the instantiated `SampleClass` variable and returns the result of the addition method. The following line is used to display the result of the `addem()` method to the console screen:

```
System.Console.WriteLine("The result is: {0}", sample.addem());
```

The symbol `{0}` is used as a placement value to represent a variable listed after the text string, in this case replaced with the return value of the `sample.addem()` method. You can add additional variables by continuing the placement numbers ({1}, {2}, and so on). Each additional variable is added to the variable list separated by commas.

After typing the program code, you must save the file using a `.CS` extension, which identifies the file as a C# code file. Once you save the file, you are ready to compile it.

Compiling and Running C# Programs

The .NET Framework SDK and Redistributable packages both contain the C# compiler, `csc.exe`. Any C# program, no matter how complex, can be compiled using just this compiler. Many different switches can be used on the command line to control the behavior of the compiler function. Some of the most common are listed in Table 1.1.

TABLE 1.1: csc Command Line Switches

Switch	Function
`/out:`*`filename`*	Defines the executable filename of the program
`/main:`*`classname`*	Defines the class that contains the `Main()` method
`/target:`*`target`*	Defines the type of program. The *`target`* can be `exe` for console-based apps, `winexe` for Windows graphical apps, `library` for Windows DLL files, or `module` for assembly modules
`/debug:`*`type`*	Creates debugging information for the executable file. The *`type`* can be `full` (the default), which enables attaching the debugger to a running process, or it can be `pdbonly`, which only creates a `.pdb` database file for debugging within a debugging tool
`/resource:<`*`res`*`>`	Embeds the resource specified in the executable file

After you determine what command-line options (if any) you need, compiling the C# program using the `csc` command-line compiler is simple:

```
C:\>csc SampleClass.cs
Microsoft (R) Visual C# .NET Compiler version 7.00.9466
for Microsoft (R) .NET Framework version 1.0.3705
Copyright (C) Microsoft Corporation 2001. All rights reserved.

C:\>
```

The compile was successful if the command prompt returns with no text messages. If any errors or warnings are indicated by the C# compiler, you must edit the source code file to correct them. Each error or warning produced by the compiler indicates the line where the error occurred. Here is an example of the error produced by `csc` when a typo occurs within the source code:

```
C:\>csc SampleClass.cs
Microsoft (R) Visual C# .NET Compiler version 7.00.9466
for Microsoft (R) .NET Framework version 1.0.3705
Copyright (C) Microsoft Corporation 2001. All rights reserved.

SampleClass.cs(36,12): error CS0117: 'System.Convert' does not contain a
        definition for 'oInt16'

C:\>
```

Note the line number, along with position in the line, shown in parentheses within the error message. Also, you get a fairly descriptive error message, helping you to determine the cause of the error. If you are using a text editor that supports line numbers, it is easy to go back into the source code and correct the mistake. If not, happy counting!

Once you successfully compile the program, you can run it from the command line:

```
C:\>SampleClass 5 10
The result is: 15

C:\>
```

You can see that the program has successfully run and displayed the result of the addition of the command-line arguments. Of course, this simple example does not do much error checking on the command-line arguments, so be careful to only enter numbers or the program will blow up and produce an error message—but more on that later in the C# Exception Programming section.

Using Multiple Source Files

The `SampleClass.cs` example program defined two separate classes in one source code file. This was easy to do for a small example, but larger programs can get confusing when you're combining classes into one source code file. Often it is best to create a separate source code file for each class used in the application. This allows better code management, especially when several people are working on an application that contains hundreds of classes. For example, two separate files could be created:

- `DataClass.cs` for the `DataClass` class code
- `SampleClass2.cs` for just the `SampleClass` class code

There are a few things to be careful of when you separate classes out into discrete source code files. First, you must ensure that the C# compiler can find them at compile time. The easiest way to do this is to include all related source code files on the command line, as follows:

```
C:\>csc SampleClass2.cs DataClass.cs
```

Be careful when you do this, however, because the source code file listed first will be the default `.exe` filename. If you want to change the `.exe` filename, you can use the `/out:` command line switch:

```
C:\>csc /out:SampleClass2.exe DataClass.cs SampleClass2.cs
```

Another issue is the importance of telling the compiler where the program execution starts. If only one class has a `Main()` section defined, this will work fine. However, sometimes different classes can use methods from other classes, but both classes may contain a `Main()` method. This would confuse the compiler, as it would not know from which `Main()` method to start to run the program.

A command-line switch for the `csc.exe` program solves this problem. The `/main:`*`switch`* defines the class that contains the `Main()` method you want to use:

```
C:\>csc /main:SampleClass SampleClass2.cs DataClass.cs
```

Notice that you must specify the class that the `Main()` method is in, not the source code filename.

Debugging C# Programs

The .NET Framework SDK offers two excellent ways to debug C# programs:

- `dbgclr` is a GUI debugging program
- `cordbg` is a command-line text debugging program

The graphical `dbgclr` program and the text mode `cordbg` program have similar features but present different interfaces. Both allow you to step through the C# program and watch variables and outputs as execution proceeds. To do this, though, you must compile the executable program using the `/debug` option on the `csc` compiler:

```
C:\>csc /debug SampleClass.cs
```

This command performs two actions: an attribute is set in the executable file that informs the CLR JIT compiler that code tracking must be done, and a programmer database (PDB) file is created that contains code tracking information for the debugger. The added attribute is called the JITTracking flag. It informs the CLR JIT compiler that the code must be disassembled from the generated native code back to MSIL instructions and ultimately mapped back to the original source code. All of this information is contained in the PDB file for the executable file.

Using the dbgclr Program

The `dbgclr` program provides a Windows environment that can be used to watch and trace a running C# program to look for coding errors. The `dbgclr` program is located under the `Microsoft.Net` directory you specified when installing the SDK. The default location is as follows:

```
C:\Progam Files\Microsoft.Net\FrameworkSDK\GuiDebug\dbgclr.exe
```

When `dbgclr` is run, you must specify the source code and executable file location for the application. To do this, follow these steps:

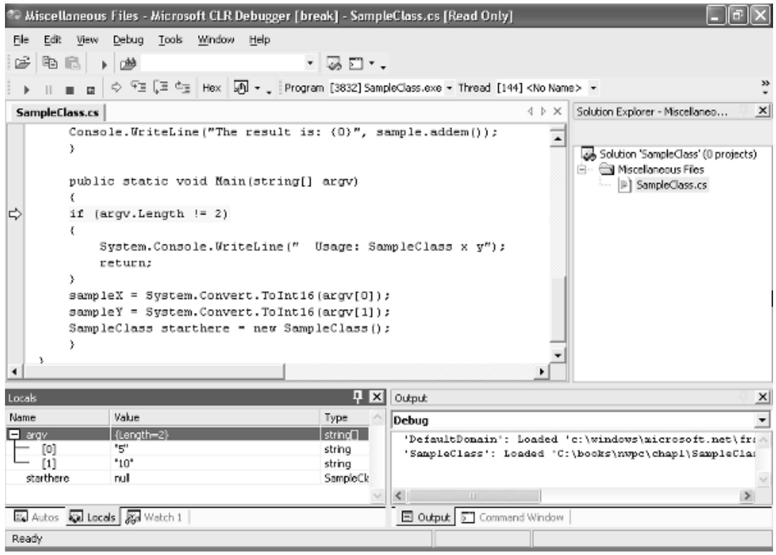
1. From the Menu Bar, click Debug ➢ Program to Debug.
2. Next to the Program text box, click the ellipsis (...) button and select the `SampleClass.exe` program you want to debug. (Remember that the executable program must have been compiled with the `/debug` switch.) The Working Directory text box will automatically display the directory location of the executable file. Also, in the Arguments text box, type in any required arguments for the program; for the SampleClass program, type in any two numbers. Click OK when you are finished.
3. Click File ➢ Open ➢ File. Select the `SampleClass.cs` source code file for the application, and click Open.

At this point, the `dbgclr` program will display four separate windows:

- The source code file
- The Solution Explorer
- The application output
- The command window

You should see the `SampleClass.cs` file in the source code window, and the Solution Explorer should list this file in the Miscellaneous Files section. To start debugging, from the menu bar, click Debug ➢ Step Into. This starts the program and allows you to single step though the code (see Figure 1.4).

FIGURE 1.4: Using `dbgclr` to single-step through an application



When the debugging process starts, a new window appears showing various variables used within the application code. Note in Figure 1.4 that the command-line argument values you entered are displayed under the Locals tab, along with the `Length` value (which should be 2). This allows you to easily watch variable values throughout the execution of the program. This is handy if you are getting a corrupt variable value within the program and want to investigate.

The Step Into function starts executing the program line by line, starting at the `Main()` section. The current code line is highlighted in yellow. By pressing F11, you can single step through the entire program. You can also click buttons on the toolbar to step over code, as well as step out of (or back up from) a code segment. This gives you great control in watching the program execute.

Using the cordbg Program

The `cordbg` command-line tool has similar functionality to that of `dbgclr`, without the graphical windows. It, too, allows you to single step through a program and monitor variable values as you go along, but with allowing text input and providing a text output. Listing 1.2 shows a sample debug session using `cordbg`.

Listing 1.2 Sample output from cordbg

```
C:\>cordbg
Microsoft (R) Common Language Runtime Test Debugger Shell Version 1.0.3705.0
Copyright (C) Microsoft Corporation 1998-2001. All rights reserved.

(cordbg) run SampleClass.exe 5 10
Process 356/0x164 created.
Warning    couldn't load symbols for
c:\winnt\microsoft.net\framework\v1.0.3705\ms
corlib.dll
[thread 0xff] Thread created.

031:    if (argv.Length != 2)
(cordbg) sh
026:    System.Console.WriteLine("The result is: {0}", sample.addem());
027:     }
028:
029:     public static void Main(string[] argv)
030:     {
031:*   if (argv.Length != 2)
032:    {
033:        System.Console.WriteLine("  Usage: SampleClass x y");
034:        return;
035:    }
036:    sampleX = System.Convert.ToInt16(argv[0]);
(cordbg) pro

PID=0x164 (356)  Name=C:\SampleClass.exe
        ID=1  AppDomainName=SampleClass.exe
(cordbg) p argv
argv=(0x00e718b8) array with dims=[2]
  argv[0] = (0x00e718d0) "5"
  argv[1] = (0x00e718e4) "10"
(cordbg) s

036:    sampleX = System.Convert.ToInt16(argv[0]);
(cordbg) so

037:    sampleY = System.Convert.ToInt16(argv[1]);
(cordbg) so

038:    SampleClass starthere = new SampleClass();
(cordbg) s

023:     public SampleClass()
(cordbg) s

[0007] nop
```

```
(cordbg) s

[001c] mov         ecx,0B65210h
(cordbg) s

006:     public DataClass(int x, int y)
(cordbg) s

[0007] nop
(cordbg) s

[0014] mov         dword ptr [esi+4],edi
(cordbg) s

009:    b = y;
(cordbg) s

010:     }
(cordbg) s

025:    DataClass sample = new DataClass(sampleX, sampleY);
(cordbg)
```

Note that when the `cordbg` program is started, you can use the `run` command with the filename of the executable program, along with any pertinent command-line parameters for the executable program. Alternatively, you can run the `cordbg` command with the executable program and arguments on the command line.

The `cordbg` program uses text commands to step through the program and display pertinent information. Table 1.2 describes some of the text commands that can be used.

TABLE 1.2: cordbg text commands

Command	Function
`s`	Step into one line of source code
`si`	Step into one line of source code
`so`	Step over the next line of code
`ss`	Step into the next native or IL instruction
`p` *`arg`*	Print the current value of the variable *`arg`*
`pro`	Show the system process information for the running program
`reg`	Display the CPU registers for the current thread
`run` *`prog`*	Run the progam *`prog`* in the debugger
`break`	Set or display a breakpoint in the code
`sh`	Show the current line of code, along with five lines before and after

As demonstrated, you can do everything in `cordbg` that you can in `dbgclr`. In fact, many advanced developers prefer to use `cordbg` because it can be faster than waiting for the graphical `dbgclr` program to do its thing.

Watching the C# program execute is one way to debug your application. The next section describes a tool for observing the actual MSIL code generated by the `csc` compiler and run by the CLR.

Debugging MSIL Code

If you really want to get under the hood of your program, you must look at the MSIL code—the actual code that is compiled by the CLR JIT compiler to create the native system code for the host. The .NET Framework SDK gives you a tool that helps you do this: the Microsoft Intermediate Language Disassembler (IL DASM). You must run the `ildasm.exe` program from the command line, along with the name of the CLR executable program to monitor to see the code:

```
C:\>ildasm SampleClass.exe
```

Figure 1.5 shows the IL DASM window with the classes and variables that are contained in the program. IL DASM gives you a hierarchical view of the code, separating the classes and the variables and methods within classes. To see the actual MSIL code, double-click an individual section. Figure 1.6 shows the result from clicking the `addem()` method. Even without knowing much about MSIL, you can see that this section of code retrieves two values from memory and adds them.

FIGURE 1.5:
The IL DASM window

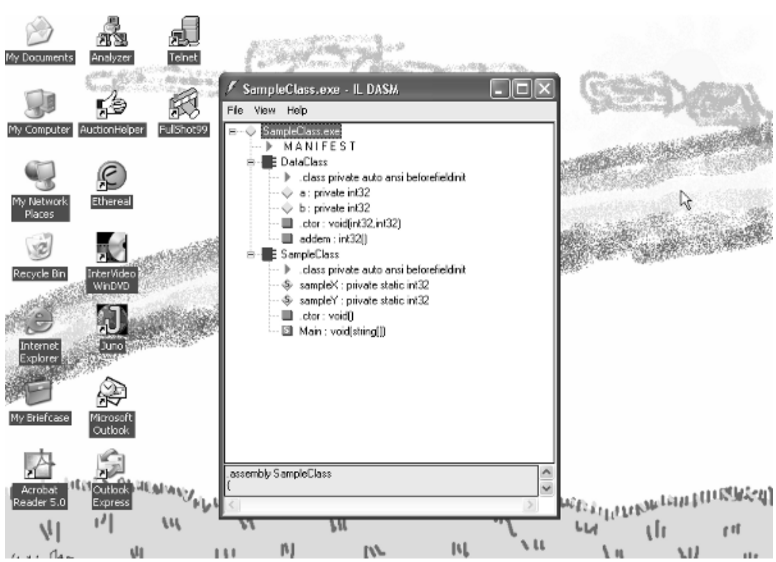
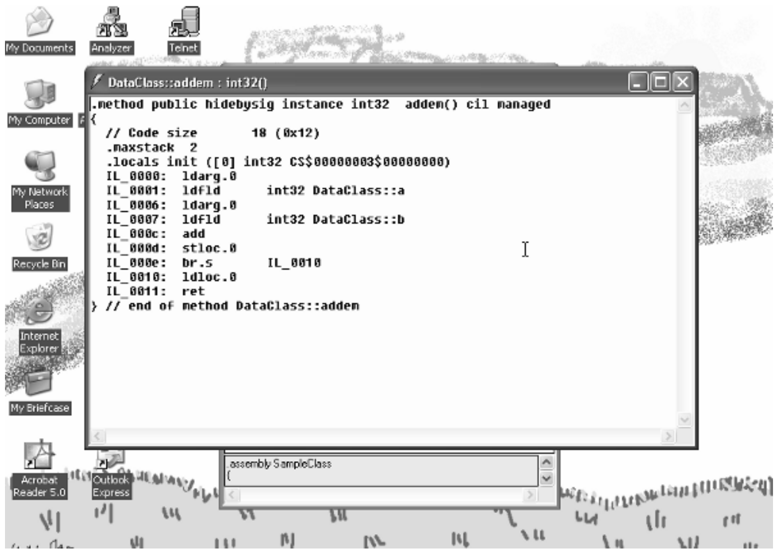


FIGURE 1.6:
MSIL code generated for the `addem()` method



NOTE If you want to debug your applications at the CLR level, you must learn the MSIL assembly code, which is way beyond the scope of this book.

Now that you are familiar with the C# development environment, it is time to start working on C# code. Let's begin by looking at some features of C# that are different from other programming languages and that are often used in network programs. If you are already familiar with the C# language, feel free to skip to the next chapter.

C# Features

C# is an object-oriented language created by Microsoft that incorporates many features that may be new to experienced C, C^{++}, and Visual Basic programmers. If you are not familiar with the C# programming language at all, I suggest you purchase a book on C# programming, such as Sybex's *Mastering Visual C# .NET* by Jason Price and Michael Gunderloy, or *Visual C# .NET Programming* by Harold Davis, also from Sybex. Texts like these fully explore the features of this exciting language. The following sections provide a brief synopsis of some unique C# features that are crucial to understand before you begin network programming.

C# Namespaces

With all of the classes provided in the .NET Framework, it's easy to get confused about which classes perform which functions and the methods that should be used from particular classes. To help simplify things, Microsoft uses *namespaces* in classifying .NET Framework classes.

What Are Namespaces?

As shown in the SampleClass program, each C# application consists of one or more classes. Each class defines an object that can contain data and methods to manipulate the data. At least one class in each application must contain a program interface method called `Main()`. The `Main()` method lets the C# compiler know where to begin execution of the program. Other classes can be defined within the program (such as the `DataClass`), or can even be shared with other programs.

Sharing classes among programs is the goal of object-oriented programming. One of the issues involved in class sharing is the importance of unique and meaningful class names. If you are working alone and on simple projects, it is unlikely that you will run into the problem of calling two (or more) classes by the same name. However, on a large development team that needs to create hundreds of classes, having a class naming structure in place is critical to success.

C# namespaces are used to identify a higher-level hierarchy of class names, allowing you to group similar classes together within a single namespace. The namespace is defined in the source code file before the class definition, using the `namespace` directive:

```
namespace Test1;

class testProgram
{

}

namespace Test2;
class testProgram
{

}
```

For programs that do not declare a namespace (such as the `SampleClass` program) the defined classes become part of a *global namespace*. These classes are globally available to any application in the CLR.

Each namespace uniquely identifies the programs within it. Notice that both of the sample namespaces just shown contain a class called `testProgram`; most likely they perform separate functions. If your program needs to use one or both of the `testProgram` classes, you must specify which class you mean to use by referencing the namespace.

The .NET Framework contains many classes separated into namespaces, which help classify the various classes into groups of common functions. You must know how to properly declare the classes you use so that there is no confusion by the compiler when your program is compiled. Let's examine the specific namespaces used in the .NET Framework.

.NET Framework Namespaces

The .NET Framework uses namespaces to help categorize library classes used in the CLR. This helps programmers determine the location of various classes and how to define them in their programs.

Many .NET Framework namespaces make up the core CLR classes. Table 1.3 lists some of the common namespaces you will encounter in your C# network applications.

TABLE 1.3: .NET Framework Class Namespaces

Namespace	Description of Classes
`Microsoft.Win32`	Handles events raised by the OS and Registry handling classes
`System`	Base .NET classes that define commonly used data types and data conversions
`System.Collections`	Defines lists, queues, bit arrays, and string collections
`System.Data`	Defines the ADO.NET database structure
`System.Data.OleDb`	Encapsulates the OLE DB .NET database structure
`System.Drawing`	Provides access to basic graphics functionality
`System.IO`	Allows reading and writing on data streams and files
`System.Management`	Provides access to the Windows Management Instrumentation (WMI) infrastructure
`System.Net`	Provides access to the Windows network functions
`System.Net.Sockets`	Provides access to the Windows sockets (Winsock) interface
`System.Runtime.Remoting`	Provides access to the Windows distributed computing platform
`System.Security`	Provides access to the CLR security permissions system
`System.Text`	Represents ACSII, Unicode, UTF-7, and UTF-8 character encodings
`System.Threading`	Enables multi-threading programming
`System.Timers`	Allows you to raise an event on a specified interval
`System.Web`	Enables browser and web server functionality
`System.Web.Mail`	Enables sending mail messages
`System.Windows.Forms`	Creates Windows-based application using the standard Windows graphical interface
`System.XML`	Provides support for processing XML documents

Using Namespaces in Programs

As explained, each namespace provides support for a specific group of classes. Once you have located the namespaces that contain the classes you need for your program, you must define them in your program to access the classes. There are two methods of identifying .NET Framework classes in your programs.

The first method was demonstrated in the SampleClass program:

```
System.Console.WriteLine("The result is {0}", sample.addem());
```

This command uses the `WriteLine()` method of the `Console` class, found in the `System` namespace. Notice the hierarchy used in referencing the method. First the namespace is declared, followed by the class name, and finally the method name. You can reference all of the .NET Framework classes in your program using this method, but you might quickly get tired of typing.

An easier way is to declare the namespace with the C# `using` directive at the beginning of the program. Any classes contained within a namespace declared with `using` do not have to be referenced by their namespace name:

```
using System;

Console.WriteLine("The result is {0}", sample.addem());
```

The C# compiler searches all declared namespaces for the `Console` class and automatically references the proper namespace.

WARNING Be careful using this method of declaring namespaces, because you can run into situations where two declared namespaces have classes with the same name (such as the `Timer` class). In that case, you must supply the full namespace name when referencing the class. If you don't, the C# compiler will complain that it cannot determine which class you are trying to reference.

After the namespaces have been declared and you use the namespace classes in your program, you must ensure that the C# compiler can find the proper class libraries when you compile your program. The next section explains how this is done.

Compiling Programs with Namespaces

The .NET Framework implements the CLR class library as a set of DLL files. Each DLL file contains a specific subset of classes from one or more namespaces. Not only must the DLLs be available when you run your .NET program, they must also be referenced on the command line when you compile the program.

You must reference each DLL that is necessary to support all of the namespaces declared in your program. To reference a DLL, you use the `/resource` command-line switch for the csc compiler:

```
C:\> csc /r:System.dll SampleClass.cs
```

(The `/resource` switch can be abbreviated `/r`.) Here, the classes for the `System` namespace are contained in the `System.dll` file, so you need to reference the `System.dll` file on the command line for the `SampleClass.cs` program to compile properly. You may be wondering why you didn't have to do this when you compiled the program earlier. There is a trick involved.

The `csc.exe` compiler program uses a configuration file that sets a few standard command-line parameters, including default DLL files to reference. The configuration file is called `csc.rsp` and is located in the same directory as the `csc.exe` program file.

You can examine the `csc.rsp` file with any text editor, such as Microsoft Notepad. Listing 1.3 shows the default `csc.rsp` file that was installed with my version of the .NET Framework.

Listing 1.3 Default csc.rsp file

```
# This file contains command-line options that the C#
# command line compiler (CSC) will process as part
# of every compilation, unless the "/noconfig" option
# is specified.

# Reference the common Framework libraries
/r:Accessibility.dll
/r:Microsoft.Vsa.dll
/r:System.Configuration.Install.dll
/r:System.Data.dll
/r:System.Design.dll
/r:System.DirectoryServices.dll
/r:System.dll
/r:System.Drawing.Design.dll
/r:System.Drawing.dll
/r:System.EnterpriseServices.dll
/r:System.Management.dll
/r:System.Messaging.dll
/r:System.Runtime.Remoting.dll
/r:System.Runtime.Serialization.Formatters.Soap.dll
/r:System.Security.dll
/r:System.ServiceProcess.dll
/r:System.Web.dll
/r:System.Web.RegularExpressions.dll
/r:System.Web.Services.dll
/r:System.Windows.Forms.Dll
/r:System.XML.dll
```

Notice that the majority of the prevalent namespace DLLs are referenced in the `csc.rsp` file. This is a handy feature that keeps you from having to reference lots of files on the command line if you are using classes from several namespaces. As shown in the comment text from the `csc.rsp` file, you can also override the `csc.rsp` values by using the `/noconfig` command-line switch:

```
C:\>csc /noconfig /r:System.dll SampleClass.cs
```

This command will compile the SampleClass program with just the reference to the `System.dll` file.

NOTE Adding references to additional DLL files does not increase the size of the resulting executable file. The references are only for the purpose of telling the compiler where to find the namespace definitions, not for compiling in the DLL code. The library class code is still run from the DLL. That is why the .NET Framework must be installed on the target workstation or server.

Using Strings in C# Programs

One of the most difficult parts of C programming is dealing with strings. Many program security holes develop from string *buffer overflows*, in which programmers have used character arrays for strings, and hackers place more characters than memory bytes allocated for the string. To alleviate some of the problems of dealing with strings in C# programs, Microsoft has incorporated two string handling classes into the C# language. Because many network protocols are concerned with sending and receiving text strings, it's a good idea to get a handle on using strings properly in C# network programs. This section will help you do that by discussing the use of .NET string classes in the C# language.

The String Class

The basic part of string support in C# is the `String` class. The `String` class allows you to assign a series of characters to a variable and handle the variable in your program as a single unit. The `String` class also contains several methods that can be used to perform operations on string objects, such as determining the length of the string and comparing two strings.

The `String` constructor is overloaded, providing several ways to create a string variable. Table 1.4 describes the string constructors.

TABLE 1.4: String Constructors

Constructor	Description
`string(char[])`	Creates a string from a specified character array
`string(char, int)`	Creates a string from a specified character repeated *int* number of times
`string(char[], int1, int2)`	Creates a string from a specified character array, starting at position *int1* with a length of *int2* bytes

In one of the few quirks of C#, you can define strings using either a capital `S` or a lowercase `s` in the `String` declaration. The following are a few examples of declaring string variables:

```
string test = "This is a test string";
string test2 = test;
string anotherTest = new string('a', 10);
```

The first technique just listed is the most common way to create new strings. After the string is created, several other methods are available for manipulating and operating on the string. Table 1.5 shows some of the more popular methods.

TABLE 1.5: String Methods

Method	Description
`Clone`	Returns a reference to the string
`Compare`	Compares two specified strings
`CompareTo`	Compares a string with another object
`Concat`	Concatenates two strings
`Copy`	Creates a new string with the value of an existing string
`CopyTo`	Copies a specified number of characters from one string, starting at a specified location, to another string
`EndsWith`	Determines if a string ends with a specified string
`Equals`	Determines if two strings have the same value
`IndexOf`	Returns the first occurrence of a specified string within the string
`Insert`	Inserts a specified string at a specified location of the string
`Intern`	Retrieves the system reference for the string
`Join`	Concatenates a specified string between each element of the string array

Continued on next page

TABLE 1.5 CONTINUED: String Methods

Method	Description
`LastIndexOf`	Returns the index location of the last occurrence of the specified string in the string
`PadLeft`	Right-aligns the characters of the string and sets the left-most characters to spaces
`PadRight`	Left-aligns the characters of the string and sets the right-most characters to spaces
`Remove`	Deletes a specified number of characters from the string
`Replace`	Replaces all occurrences of a specified character or string with another specified character or string
`Split`	Identifies substrings in the string based on a specified separation character
`StartsWith`	Determines if a string starts with a specified string
`ToCharArray`	Copies the characters in the string to a character array
`ToLower`	Returns a copy of the string, setting all characters to lowercase
`ToString`	Converts the value of the object to a string
`ToUpper`	Returns a copy of the string, setting all characters to uppercase
`Trim`	Removes all occurrences of a set of specified characters from the beginning and end of a string
`TrimEnd`	Removes all occurrences of a set of specified characters from the end of a string
`TrimStart`	Removes all occurrences of a set of specified characters from the beginning of a string

With all of these string methods at your disposal, it is easy to work with strings in C# programs. Much of the hard work of manipulating and comparing strings has been done for you. Listing 1.4 shows a sample string program to illustrate some of these features.

Listing 1.4 **Sample string program StringTest.cs**

```
using System;

class StringTest
{
    public static void Main ()
    {
        string test1 = "This is a test string";
        string test2, test3;

        test2 = test1.Insert(15, "application ");
        test3 = test1.ToUpper();

        Console.WriteLine("test1: '{0}'", test1);
        Console.WriteLine("test2: '{0}'", test2);
        Console.WriteLine("test3: '{0}'", test3);

        if (test1 == test3)
            Console.WriteLine("test1 is equal to test3");
```

```
        else
            Console.WriteLine("test1 is not equal to test3");

        test2 = test1.Replace("test", "sample");
        Console.WriteLine("the new test2: '{0}'", test2);

    }
}
```

The output from this program should look like this:

```
C:\>StringTest
test1: 'This is a test string'
test2: 'This is a test application string'
test3: 'THIS IS A TEST STRING'
test1 is not equal to test3
the new test2: 'This is a sample string'

C:\>
```

C# creates a set amount of memory for each new string created. Because of this, strings are *immutable*, that is, they cannot be changed. That said, you may see C# code like the following:

```
string newString = new string("test");
string newString += "ing";
```

The resulting value for the variable *`newString`* is `testing`.

If strings are immutable, how can you modify an existing string? The answer is, you don't; C# just does some trickery. Instead of modifying the existing string, C# creates a brand new string with the new value. The memory area reserved for the old string is now unused and will be cleaned up on the next garbage collection cycle (CLR's automatic recovery of lost memory). If you do a lot of string manipulation in your programs, these operations can create additional memory overhead. To compensate for this, Microsoft has created another type of string class just for modifying string objects.

The StringBuilder Class

As its name suggests, the `StringBuilder` class allows you to create and modify strings without the overhead of recreating new strings each time. It generates a mutable sequence of characters that can change size dynamically as the string is modified, allocating more memory as required.

The amount of memory used by the string is called the *capacity*. The default capacity of a `StringBuilder` string is currently set to 16 bytes (`StringBuilder` documentation indicates that this value may change in the future). If you create a string larger than 16 bytes, `StringBuilder` will automatically attempt to allocate more memory. When you want to control exactly how much memory `StringBuilder` can use, you can manually increase or decrease the string capacity using `StringBuilder` methods, as well as various `StringBuilder` constructors when the instance is initially created.

Six constructors can be used to create a `StringBuilder` instance, as shown in Table 1.6.

TABLE 1.6: The StringBuilder Class Constructors

Constructor	Description
`StringBuilder()`	Initializes a new default instance with a size of 16
`StringBuilder(`*`int`*`)`	Initializes a new instance with a capacity of *`int`*
`StringBuilder(`*`string`*`)`	Initializes a new instance with a default value of *`string`*
`StringBuilder(`*`int1`*`, `*`int2`*`)`	Initializes a new instance with a default capacity of *`int1`* and a maximum capacity of *`int2`*
`StringBuilder(`*`string`*`, `*`int`*`)`	Initializes a new instance with a default value of *`string`* and a capacity of *`int`*
`StringBuilder(`*`string`*`, `*`int1`*`, `*`int2`*`, `*`int3`*`)`	Initializes a new instance with a default value starting at position *`int1`* of *`string`*, *`int2`* characters long, with a capacity of *`int3`*

Once the `StringBuilder` instance is created, you have access to several properties, methods, and operations for modifying and checking properties of the string. One of the most useful properties is `Length`, which allows you to dynamically change the capacity of the string. Listing 1.5 shows an example of changing the capacity of the `StringBuilder` string using the `Length` property.

Listing 1.5 **The SampleBuilder.cs program**

```
using System;
using System.Text;

class SampleBuilder
{

    public static void Main ()
    {

        StringBuilder sb = new StringBuilder("test string");
        int length = 0;

        length = sb.Length;
        Console.WriteLine("The result is: '{0}'", sb);
        Console.WriteLine("The length is: {0}", length);

        sb.Length = 4;
        length = sb.Length;
        Console.WriteLine("The result is: '{0}'", sb);
        Console.WriteLine("The length is: {0}", length);
```

```
            sb.Length = 20;
            length = sb.Length;
            Console.WriteLine("The result is: '{0}'", sb);
            Console.WriteLine("The length is: {0}", length);

        }
    }
```

The output from the StringSample program should look like this:

```
C:\>SampleBuilder
The result is: 'test string'
The length is: 11
The result is: 'test'
The length is: 4
The result is: 'test                '
The length is: 20

C:\>
```

The original string is 11 bytes long, but after setting the string length to 4, the resulting string is only the first 4 bytes of the original string. After setting the string length to 20, the string becomes 20 bytes long, but the data originally located after the fourth byte has been lost, with spaces used to pad the extra bytes.

After the final string is built using a `StringBuilder` object, you may need to convert it to a string object to send it to a network stream. This is a simple process using the `ToString()` method:

```
string outbound = sb.ToString();
```

Now the `string outbound` can be used as a normal string object. Just remember that it is now an immutable string, and as such should not be modified (or be aware that you may suffer additional overhead if it is).

Streams, mentioned in the preceding paragraph, are another feature of C# that you should know intimately for network programming. The next section describes C# streams and their uses.

C# Streams

Data handling is one of the most important jobs of programs. There are many methods for storing and retrieving data in the C# world—files, memory, input/output devices, interprocess communication pipes, and networks. There are also many ways of reading data to and writing it from objects. Most objects allow data to be read or written on a byte-by-byte basis. This method transfers one byte of data into or out of the data object at a time. Certainly this works, but it is not the most efficient manner of handling data.

The C# language supplies an interface to assist programmers in moving large chunks of data to and from data objects. The data *stream* allows multiple bytes of data to be transferred simultaneously to a data object so that programs can work on blocks of data instead of having to build data elements one byte at a time.

Streams can support three fundamental operations:

- Transferring data from a stream to a memory buffer (reading)
- Transferring data from a memory buffer to a stream (writing)
- Searching the stream for a specific byte pattern (seeking)

Not all streams support all of these functions. Obviously, a CD-ROM device cannot support streams that write data, and network connections do not support streams that seek data patterns.

The .NET `System.IO` namespace contains various stream classes that can be used to combine the bytes from a data source into manageable blocks that are easier to manipulate.

The `FileStream` class is a good example of using a stream to simplify reading and writing data. This class provides a stream interface to easily read and write data to a disk file. Let's look at an example.

If you were writing a program that logged messages to a log file, you most likely would be logging (writing out) one text line of information at a time. You would write the code to place each string in the file byte-by-byte, and ensure that the proper carriage return was added to each text line as it was written. Then, when you wanted to read the log file with a program, you would have to create the code to read the file byte-by-byte. As the file was read, you would have to know that each log file entry ended with the carriage return and that a new entry would start. Each byte read would have to be examined to determine if it was a carriage return.

Instead of this tedious process, you can take advantage of the `FileStream` class, along with the `StreamWriter` class, to easily write and read lines of text in a log file. Listing 1.6 shows a sample program that uses streams to simplify file access.

Listing 1.6 Sample log writing program TestLog.cs

```
using System;
using System.IO;

class TestLog
{
     public static void Main ()
    {
        string logFile = "LOGFILE.TXT";

        FileStream fs = new FileStream(logFile,
```

```
                  FileMode.OpenOrCreate, FileAccess.ReadWrite);

            StreamWriter sw = new StreamWriter(fs);
            StreamReader sr = new StreamReader(fs);

            sw.WriteLine("First log entry");
            sw.WriteLine("Second log entry");

            while(sr.Peek() > -1)
            {
                Console.WriteLine(sr.ReadLine());
            }

            sw.Close();
            sr.Close();
            fs.Close();
        }
    }
```

Take note of the following things in this example:

- The `FileStream` object can be used for both reading data from and writing data to the stream.
- Both the `StreamReader` and `StreamWriter` objects reference the same `FileStream`, but they perform different functions.
- Each stream object has its own pointer in the stream. After the `StreamWriter` object inserts two new lines in its stream, the `StreamReader` object reads the first object in its stream, which is the first line in the file.
- Each stream opened must be explicitly closed, including the base `FileStream` object. Many novice programmers forget to close the base stream and inadvertently leave it hanging.

The most common stream technique is to create two separate streams for reading and writing:

```
StreamWriter sw = new StreamWriter(fs);
StreamReader sr = new StreamReader(fs);
```

This enables you to have complete control over data access to and from the stream using separate streams.

One thing this program doesn't do is error checking on the file open attempt. If the program is not able to open the log file, it will produce an ugly error message to the user. The next section shows how you can gracefully handle error conditions within C# programs.

C# Exception Programming

One of the biggest problems for programmers is dealing with abnormal conditions in a program. Inexperienced programmers often forget to compensate for error conditions such as dividing by zero. This results in ugly and annoying error messages and programs blowing up in customers' faces. To ensure that your code is user-friendly, try to compensate for most types of error conditions. Such error conditions, or other unexpected behavior occurring when a program executes, are called e*xceptions*. Listing 1.7 shows an example.

Listing 1.7 The BadError.cs program

```
using System;

class BadError
{
    public static void Main ()
    {
        int var1 = 1000, var2 = 0, var3;

        var3 = var1 / var2;
        Console.WriteLine("The result is: {0}", var3);
    }
}
```

As you can see, this program is doomed from the start. The arithmetic function in line 9 is destined for disaster because of a divide-by-zero error. Compile and run this example and watch what happens:

```
C:\>csc BadError.cs
Microsoft (R) Visual C# .NET Compiler version 7.00.9466
for Microsoft (R) .NET Framework version 1.0.3705
Copyright (C) Microsoft Corporation 2001. All rights reserved.


C:\>BadError

Unhandled Exception: System.DivideByZeroException: Attempted to divide by zero.
   at BadError.Main()

C:\>
```

The csc compiler had no problem compiling this code. It was oblivious to the impending error. When the program runs, a pop-up window indicates that an error occurred and asks you if you want to debug the application. This is exactly the kind of thing you do not want your customers to see. After clicking the OK button, the text error message is produced on the console, indicating the error that was encountered. The program halts at the line of code that produced the error, and no other lines are executed.

C# helps programmers code for exceptions by providing a way to watch and capture exceptions as they occur. By catching exceptions, programmers can efficiently provide for readable error messages and the continuation of the program, or they can stop the program gracefully if necessary. In C#, the `try-catch` block accomplishes this.

The `try-catch` block tries to execute one or more statements. If any of the statements generates an exception, the `catch` block of code is executed instead of the program stopping. Depending on what you include in the `catch` block, the program can either be terminated gracefully, or allowed to continue as if nothing were wrong. Here is the format of a `try-catch` block:

```
try
{
    // one or more lines of code
}
catch ()
{
    // one or more lines of code to execute if an error
}
finally
{
   // one or more lines of code to execute at all times
}
```

The statements in the `try` block are executed as normal within the course of the program. If an error condition occurs within the `try` block, program execution moves to the `catch` block. After the code in the `catch` block is executed, control passes back to the main program statements that follow the `try-catch` block, as if no error had occurred (unless of course the code in the `catch` block stops or redirects the program execution).

Optionally, you can add a `finally` block, which will be executed after the `try` or the `catch` blocks are finished. Sometimes the `finally` block is used for clean-up functions that *must* run whether the functions succeed or fail; most often, however, `finally` is not used.

NOTE Notice the parentheses in the `catch` statement. This is a filter, allowing you to define what types of exceptions you want to attempt to catch. You can define a specific exception to watch for, depending on the type of actions being done in the `try` block; or you can define the generic `Exception` class, which will catch any exception that occurs. You can even define more than one `catch` block. `Catch` blocks are evaluated in order, so specific exceptions must be listed before general ones.

Listing 1.8 shows an example of a simple `try-catch` block.

Listing 1.8 The CatchError.cs program

```
using System;

class CatchError
{
    public static void Main ()
    {
        int var1 = 1000, var2 = 0, var3;

        try
        {
            var3 = var1 / var2;
        }
        catch (ArithmeticException e)
        {
            Console.WriteLine("Exception: {0}",
                     e.ToString());
            var3 = -1;
        }
        catch (Exception e)
        {
            Console.WriteLine("Exception: {0}",
                     e.ToString());
            var3 = -2;
        }
        Console.WriteLine("The result is: {0}", var3);
    }
}
```

In CatchError, the original program is modified by adding a `try-catch` block. There are two `catch` statements: one to watch specifically for `ArithmeticExceptions`, and one to watch for any general `Exception`. Notice that the specific `ArithmeticException` was listed first, otherwise the general `Exception` block would handle all of the exceptions before the more detailed exception appeared. Also note that the `catch` blocks set a value for the result variable that can then be checked later on in the program. The result of this program is as follows:

```
C:\>csc CatchError.cs
Microsoft (R) Visual C# .NET Compiler version 7.00.9466
for Microsoft (R) .NET Framework version 1.0.3705
Copyright (C) Microsoft Corporation 2001. All rights reserved.


C:\>CatchError
Exception: System.DivideByZeroException: Attempted to divide by zero.
   at CatchError.Main()
The result is: -1

C:\>
```

The `try-catch` block gracefully catches the arithmetic exception, displays the error as instructed in the `catch` block, and sets the variable to a special value that can later be checked in the program logic.

NOTE Network functions are frequently used within `try-catch` blocks. In network programming, it is often impossible to determine whether an action will succeed. For example, packets sent out on the network may not get to their intended destination because of a down router or destination host. Instead of the program blowing up because of an unexpected network issue, the problem can be reported to the user.

Summary

The Microsoft .NET technology supplies an excellent programming environment for network programmers. The C# programming language allows programmers to easily prototype applications in a short amount of time and lets them design robust network applications that take advantage of the Windows networking features.

Creating a C# development environment is easy with the two comprehensive Microsoft Visual .NET products or the new .NET Framework SDK package. All three environments include compilers and debuggers for creating C# application programs.

The C# language also offers many features that smooth the way for programmers writing network applications. For instance, using the `StringBuilder` class instead of creating and modifying string objects may save your application some performance time. Also, putting streams to work in network programming can simplify handling of data into and out of the network transport. Using exceptions in your programs can make your applications look more professional and save your customers lots of grief.

This chapter discussed the basics of the C# language, and you'll find more basics in Chapter 3. There we'll get into the specific C# classes used for network programming. With the addition of network programming helper classes, C# makes network programming a snap. First, though, Chapter 2 presents a helpful review of IP programming fundamentals.