Contents

Assemblies and the Global Assembly Cache (C#)

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Assemblies form the fundamental unit of deployment, version control, reuse, activation scoping, and security permissions for a .NET-based application. Assemblies take the form of an executable (.exe) file or dynamic link library (.dll) file, and are the building blocks of the .NET Framework. They provide the common language runtime with the information it needs to be aware of type implementations. You can think of an assembly as a collection of types and resources that form a logical unit of functionality and are built to work together.

Assemblies can contain one or more modules. For example, larger projects may be planned in such a way that several individual developers work on separate modules, all coming together to create a single assembly. For more information about modules, see the topic How to: Build a Multifile Assembly.

Assemblies have the following properties:

- Assemblies are implemented as .exe or .dll files.
- You can share an assembly between applications by putting it in the global assembly cache. Assemblies must be strong-named before they can be included in the global assembly cache. For more information, see Strong-Named Assemblies.
- Assemblies are only loaded into memory if they are required. If they are not used, they are not loaded. This means that assemblies can be an efficient way to manage resources in larger projects.
- You can programmatically obtain information about an assembly by using reflection. For more information, see Reflection (C#).
- If you want to load an assembly only to inspect it, use a method such as ReflectionOnlyLoadFrom.

Assembly Manifest

Within every assembly, there is an *assembly manifest*. Similar to a table of contents, the assembly manifest contains the following:

- The assembly's identity (its name and version).
- A file table describing all the other files that make up the assembly, for example, any other assemblies you created that your .exe or .dll file relies on, or even bitmap or Readme files.
- An *assembly reference list*, which is a list of all external dependencies—.dlls or other files your application needs that may have been created by someone else. Assembly references contain references to both global and private objects. Global objects reside in the global assembly cache, an area available to other applications. Private objects must be in a directory at either the same level as or below the directory in which your application is installed.

Because assemblies contain information about content, versioning, and dependencies, the applications you create with C# do not rely on Windows registry values to function properly. Assemblies reduce .dll conflicts and make your applications more reliable and easier to deploy. In many cases, you can install a .NET-based application simply by copying its files to the target computer.

For more information see Assembly Manifest.

Adding a Reference to an Assembly

To use an assembly, you must add a reference to it. Next, you use the using directive to choose the namespace of the items you want to use. Once an assembly is referenced and imported, all the accessible classes, properties, methods, and other members of its namespaces are available to your application as if their code were part of your source file.

In C#, you can also use two versions of the same assembly in a single application. For more information, see extern alias.

Creating an Assembly

Compile your application by clicking **Build** on the **Build** menu or by building it from the command line using the command-line compiler. For details about building assemblies from the command line, see Command-line Building With csc.exe.

NOTE

To build an assembly in Visual Studio, on the **Build** menu choose **Build**.

See also

- C# Programming Guide
- Assemblies in the Common Language Runtime
- Friend Assemblies (C#)
- How to: Share an Assembly with Other Applications (C#)
- How to: Load and Unload Assemblies (C#)
- How to: Determine If a File Is an Assembly (C#)
- How to: Create and Use Assemblies Using the Command Line (C#)
- Walkthrough: Embedding Types from Managed Assemblies in Visual Studio (C#)
- Walkthrough: Embedding Type Information from Microsoft Office Assemblies in Visual Studio (C#)

Friend Assemblies (C#)

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A *friend assembly* is an assembly that can access another assembly's internal types and members. If you identify an assembly as a friend assembly, you no longer have to mark types and members as public in order for them to be accessed by other assemblies. This is especially convenient in the following scenarios:

- During unit testing, when test code runs in a separate assembly but requires access to members in the assembly being tested that are marked as `internal` .
- When you are developing a class library and additions to the library are contained in separate assemblies but require access to members in existing assemblies that are marked as `internal` .

Remarks

You can use the InternalsVisibleToAttribute attribute to identify one or more friend assemblies for a given assembly. The following example uses the InternalsVisibleToAttribute attribute in assembly A and specifies assembly `AssemblyB` as a friend assembly. This gives assembly `AssemblyB` access to all types and members in assembly A that are marked as `internal`.

NOTE

When you compile an assembly (assembly `AssemblyB`) that will access internal types or internal members of another assembly (assembly *A*), you must explicitly specify the name of the output file (.exe or .dll) by using the **/out** compiler option. This is required because the compiler has not yet generated the name for the assembly it is building at the time it is binding to external references. For more information, see /out (C#) .

```
using System.Runtime.CompilerServices;
using System;

[assembly: InternalsVisibleTo("AssemblyB")]

// The class is internal by default.
class FriendClass
{
    public void Test()
    {
        Console.WriteLine("Sample Class");
    }
}

// Public class that has an internal method.
public class ClassWithFriendMethod
{
    internal void Test()
    {
        Console.WriteLine("Sample Method");
    }

}
```

Only assemblies that you explicitly specify as friends can access `internal` types and members. For example, if assembly B is a friend of assembly A and assembly C references assembly B, C does not have access to `internal` types in A.

The compiler performs some basic validation of the friend assembly name passed to the InternalsVisibleToAttribute attribute. If assembly *A* declares *B* as a friend assembly, the validation rules are as follows:

- If assembly *A* is strong named, assembly *B* must also be strong named. The friend assembly name that is passed to the attribute must consist of the assembly name and the public key of the strong-name key that is used to sign assembly *B*.

  The friend assembly name that is passed to the InternalsVisibleToAttribute attribute cannot be the strong name of assembly *B*: do not include the assembly version, culture, architecture, or public key token.

- If assembly *A* is not strong named, the friend assembly name should consist of only the assembly name. For more information, see How to: Create Unsigned Friend Assemblies (C#).

- If assembly *B* is strong named, you must specify the strong-name key for assembly *B* by using the project setting or the command-line `/keyfile` compiler option. For more information, see How to: Create Signed Friend Assemblies (C#).

The StrongNameIdentityPermission class also provides the ability to share types, with the following differences:

- StrongNameIdentityPermission applies to an individual type, while a friend assembly applies to the whole assembly.

- If there are hundreds of types in assembly *A* that you want to share with assembly *B*, you have to add StrongNameIdentityPermission to all of them. If you use a friend assembly, you only need to declare the friend relationship once.

- If you use StrongNameIdentityPermission, the types you want to share have to be declared as public. If you use a friend assembly, the shared types are declared as `internal`.

For information about how to access an assembly's `internal` types and methods from a module file (a file with the .netmodule extension), see /moduleassemblyname (C#).

See also

- InternalsVisibleToAttribute
- StrongNameIdentityPermission
- How to: Create Unsigned Friend Assemblies (C#)
- How to: Create Signed Friend Assemblies (C#)
- Assemblies and the Global Assembly Cache (C#)
- C# Programming Guide

How to: Create Unsigned Friend Assemblies (C#)

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This example shows how to use friend assemblies with assemblies that are unsigned.

To create an assembly and a friend assembly

1. Open a command prompt.
2. Create a C# file named `friend_unsigned_A.` that contains the following code. The code uses the InternalsVisibleToAttribute attribute to declare friend_unsigned_B as a friend assembly.

```
// friend_unsigned_A.cs
// Compile with:
// csc /target:library friend_unsigned_A.cs
using System.Runtime.CompilerServices;
using System;

[assembly: InternalsVisibleTo("friend_unsigned_B")]

// Type is internal by default.
class Class1
{
    public void Test()
    {
        Console.WriteLine("Class1.Test");
    }
}

// Public type with internal member.
public class Class2
{
    internal void Test()
    {
        Console.WriteLine("Class2.Test");
    }
}
```

3. Compile and sign friend_unsigned_A by using the following command.

```
csc /target:library friend_unsigned_A.cs
```

4. Create a C# file named `friend_unsigned_B` that contains the following code. Because friend_unsigned_A specifies friend_unsigned_B as a friend assembly, the code in friend_unsigned_B can access `internal` types and members from friend_unsigned_A.

```
// friend_unsigned_B.cs
// Compile with:
// csc /r:friend_unsigned_A.dll /out:friend_unsigned_B.exe friend_unsigned_B.cs
public class Program
{
    static void Main()
    {
        // Access an internal type.
        Class1 inst1 = new Class1();
        inst1.Test();

        Class2 inst2 = new Class2();
        // Access an internal member of a public type.
        inst2.Test();

        System.Console.ReadLine();
    }
}
```

5. Compile friend_unsigned_B by using the following command.

   ```
   csc /r:friend_unsigned_A.dll /out:friend_unsigned_B.exe friend_unsigned_B.cs
   ```

   The name of the assembly that is generated by the compiler must match the friend assembly name that is passed to the InternalsVisibleToAttribute attribute. You must explicitly specify the name of the output assembly (.exe or .dll) by using the `/out` compiler option. For more information, see /out (C# Compiler Options).

6. Run the friend_unsigned_B.exe file.

   The program prints two strings: "Class1.Test" and "Class2.Test".

.NET Framework Security

There are similarities between the InternalsVisibleToAttribute attribute and the StrongNameIdentityPermission class. The main difference is that StrongNameIdentityPermission can demand security permissions to run a particular section of code, whereas the InternalsVisibleToAttribute attribute controls the visibility of `internal` types and members.

See also

- InternalsVisibleToAttribute
- Assemblies and the Global Assembly Cache (C#)
- Friend Assemblies (C#)
- How to: Create Signed Friend Assemblies (C#)
- C# Programming Guide

How to: Create Signed Friend Assemblies (C#)

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This example shows how to use friend assemblies with assemblies that have strong names. Both assemblies must be strong named. Although both assemblies in this example use the same keys, you could use different keys for two assemblies.

To create a signed assembly and a friend assembly

1. Open a command prompt.

2. Use the following sequence of commands with the Strong Name tool to generate a keyfile and to display its public key. For more information, see Sn.exe (Strong Name Tool).

   a. Generate a strong-name key for this example and store it in the file FriendAssemblies.snk:

   ```
   sn -k FriendAssemblies.snk
   ```

   b. Extract the public key from FriendAssemblies.snk and put it into FriendAssemblies.publickey:

   ```
   sn -p FriendAssemblies.snk FriendAssemblies.publickey
   ```

   c. Display the public key stored in the file FriendAssemblies.publickey:

   ```
   sn -tp FriendAssemblies.publickey
   ```

3. Create a C# file named `friend_signed_A` that contains the following code. The code uses the InternalsVisibleToAttribute attribute to declare friend_signed_B as a friend assembly.

   The Strong Name tool generates a new public key every time it runs. Therefore, you must replace the public key in the following code with the public key you just generated, as shown in the following example.

   ```
   // friend_signed_A.cs
   // Compile with:
   // csc /target:library /keyfile:FriendAssemblies.snk friend_signed_A.cs
   using System.Runtime.CompilerServices;

   [assembly: InternalsVisibleTo("friend_signed_B,
   PublicKey=0024000004800000940000000602000000240000525341310004000001000100e3aedce99b7e10823920206f8e46c
   d5558b4ec7345bd1a5b201ffe71660625dcb8f9a08687d881c8f65a0dcf042f81475d2e88f3e3e273c8311ee40f952db306c02f
   bfc5d8bc6ee1e924e6ec8fe8c01932e0648a0d3e5695134af3bb7fab370d3012d083fa6b83179dd3d031053f72fc1f7da845914
   0b0af5afc4d2804deccb6")]
   class Class1
   {
       public void Test()
       {
           System.Console.WriteLine("Class1.Test");
           System.Console.ReadLine();
       }
   }
   ```

4. Compile and sign friend_signed_A by using the following command.

   ```
   csc /target:library /keyfile:FriendAssemblies.snk friend_signed_A.cs
   ```

5. Create a C# file that is named `friend_signed_B` and contains the following code. Because friend_signed_A specifies friend_signed_B as a friend assembly, the code in friend_signed_B can access `internal` types and

members from friend_signed_A. The file contains the following code.

```
// friend_signed_B.cs
// Compile with:
// csc /keyfile:FriendAssemblies.snk /r:friend_signed_A.dll /out:friend_signed_B.exe friend_signed_B.cs
public class Program
{
    static void Main()
    {
        Class1 inst = new Class1();
        inst.Test();
    }
}
```

6. Compile and sign friend_signed_B by using the following command.

```
csc /keyfile:FriendAssemblies.snk /r:friend_signed_A.dll /out:friend_signed_B.exe friend_signed_B.cs
```

   The name of the assembly generated by the compiler must match the friend assembly name passed to the InternalsVisibleToAttribute attribute. You must explicitly specify the name of the output assembly (.exe or .dll) by using the `/out` compiler option. For more information, see /out (C# Compiler Options).

7. Run the friend_signed_B.exe file.

   The program prints the string "Class1.Test".

.NET Framework Security

There are similarities between the InternalsVisibleToAttribute attribute and the StrongNameIdentityPermission class. The main difference is that StrongNameIdentityPermission can demand security permissions to run a particular section of code, whereas the InternalsVisibleToAttribute attribute controls the visibility of `internal` types and members.

See also

- InternalsVisibleToAttribute
- Assemblies and the Global Assembly Cache (C#)
- Friend Assemblies (C#)
- How to: Create Unsigned Friend Assemblies (C#)
- /keyfile
- Sn.exe (Strong Name Tool)
- Creating and Using Strong-Named Assemblies
- C# Programming Guide

How to: Create and Use Assemblies Using the Command Line (C#)

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An assembly, or a dynamic linking library (DLL), is linked to your program at run time. To demonstrate building and using a DLL, consider the following scenario:

- `MathLibrary.DLL` : The library file that contains the methods to be called at run time. In this example, the DLL contains two methods, `Add` and `Multiply` .
- `Add` : The source file that contains the method `Add` . It returns the sum of its parameters. The class `AddClass` that contains the method `Add` is a member of the namespace `UtilityMethods` .
- `Mult` : The source code that contains the method `Multiply` . It returns the product of its parameters. The class `MultiplyClass` that contains the method `Multiply` is also a member of the namespace `UtilityMethods` .
- `TestCode` : The file that contains the `Main` method. It uses the methods in the DLL file to calculate the sum and the product of the run-time arguments.

Example

```
// File: Add.cs
namespace UtilityMethods
{
    public class AddClass
    {
        public static long Add(long i, long j)
        {
            return (i + j);
        }
    }
}
```

```
// File: Mult.cs
namespace UtilityMethods
{
    public class MultiplyClass
    {
        public static long Multiply(long x, long y)
        {
            return (x * y);
        }
    }
}
```

```
// File: TestCode.cs

using UtilityMethods;

class TestCode
{
    static void Main(string[] args)
    {
        System.Console.WriteLine("Calling methods from MathLibrary.DLL:");

        if (args.Length != 2)
        {
            System.Console.WriteLine("Usage: TestCode <num1> <num2>");
            return;
        }

        long num1 = long.Parse(args[0]);
        long num2 = long.Parse(args[1]);

        long sum = AddClass.Add(num1, num2);
        long product = MultiplyClass.Multiply(num1, num2);

        System.Console.WriteLine("{0} + {1} = {2}", num1, num2, sum);
        System.Console.WriteLine("{0} * {1} = {2}", num1, num2, product);
    }
}
/* Output (assuming 1234 and 5678 are entered as command-line arguments):
    Calling methods from MathLibrary.DLL:
    1234 + 5678 = 6912
    1234 * 5678 = 7006652
*/
```

This file contains the algorithm that uses the DLL methods, `Add` and `Multiply`. It starts with parsing the arguments entered from the command line, `num1` and `num2`. Then it calculates the sum by using the `Add` method on the `AddClass` class, and the product by using the `Multiply` method on the `MultiplyClass` class.

Notice that the `using` directive at the beginning of the file enables you to use the unqualified class names to reference the DLL methods at compile time, as follows:

```
MultiplyClass.Multiply(num1, num2);
```

Otherwise, you have to use the fully qualified names, as follows:

```
UtilityMethods.MultiplyClass.Multiply(num1, num2);
```

Execution

To run the program, enter the name of the EXE file, followed by two numbers, as follows:

`TestCode 1234 5678`

Compiling the Code

To build the file `MathLibrary.DLL`, compile the two files `Add` and `Mult` by using the following command line.

```
csc /target:library /out:MathLibrary.DLL Add.cs Mult.cs
```

The /target:library compiler option tells the compiler to output a DLL instead of an EXE file. The /out compiler option followed by a file name is used to specify the DLL file name. Otherwise, the compiler uses the first file (`Add.cs`) as the name of the DLL.

To build the executable file, `TestCode.exe` , use the following command line:

```
csc /out:TestCode.exe /reference:MathLibrary.DLL TestCode.cs
```

The **/out** compiler option tells the compiler to output an EXE file and specifies the name of the output file (`TestCode.exe`). This compiler option is optional. The /reference compiler option specifies the DLL file or files that this program uses. For more information, see /reference.

For more information about building from the command line, see Command-line Building With csc.exe.

See also

- C# Programming Guide
- Assemblies and the Global Assembly Cache (C#)
- Creating a Class to Hold DLL Functions

How to: Determine If a File Is an Assembly (C#)

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A file is an assembly if and only if it is managed, and contains an assembly entry in its metadata. For more information on assemblies and metadata, see the topic Assembly Manifest.

How to manually determine if a file is an assembly

1. Start the Ildasm.exe (IL Disassembler).
2. Load the file you wish to test.
3. If **ILDASM** reports that the file is not a portable executable (PE) file, then it is not an assembly. For more information, see the topic How to: View Assembly Contents.

How to programmatically determine if a file is an assembly

1. Call the GetAssemblyName method, passing the full file path and name of the file you are testing.
2. If a BadImageFormatException exception is thrown, the file is not an assembly.

Example

This example tests a DLL to see if it is an assembly.

```
class TestAssembly
{
    static void Main()
    {

        try
        {
            System.Reflection.AssemblyName testAssembly =

System.Reflection.AssemblyName.GetAssemblyName(@"C:\Windows\Microsoft.NET\Framework\v3.5\System.Net.dll");

            System.Console.WriteLine("Yes, the file is an assembly.");
        }

        catch (System.IO.FileNotFoundException)
        {
            System.Console.WriteLine("The file cannot be found.");
        }

        catch (System.BadImageFormatException)
        {
            System.Console.WriteLine("The file is not an assembly.");
        }

        catch (System.IO.FileLoadException)
        {
            System.Console.WriteLine("The assembly has already been loaded.");
        }
    }
}
/* Output (with .NET Framework 3.5 installed):
    Yes, the file is an assembly.
*/
```

The GetAssemblyName method loads the test file, and then releases it once the information is read.

See also

- AssemblyName
- C# Programming Guide
- Assemblies and the Global Assembly Cache (C#)

How to: Load and Unload Assemblies (C#)

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The assemblies referenced by your program will automatically be loaded at build time, but it is also possible to load specific assemblies into the current application domain at runtime. For more information, see How to: Load Assemblies into an Application Domain.

There is no way to unload an individual assembly without unloading all of the application domains that contain it. Even if the assembly goes out of scope, the actual assembly file will remain loaded until all application domains that contain it are unloaded.

If you want to unload some assemblies but not others, consider creating a new application domain, executing the code inside that domain, and then unloading that application domain. For more information, see How to: Unload an Application Domain.

To load an assembly into an application domain

1. Use one of the several load methods contained in the classes AppDomain and System.Reflection. For more information, see How to: Load Assemblies into an Application Domain.

To unload an application domain

1. There is no way to unload an individual assembly without unloading all of the application domains that contain it. Use the `Unload` method from AppDomain to unload the application domains. For more information, see How to: Unload an Application Domain.

See also

- C# Programming Guide
- Assemblies and the Global Assembly Cache (C#)
- How to: Load Assemblies into an Application Domain

How to: Share an Assembly with Other Applications (C#)

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Assemblies can be private or shared: by default, most simple programs consist of a private assembly because they are not intended to be used by other applications.

In order to share an assembly with other applications, it must be placed in the Global Assembly Cache (GAC).

Sharing an assembly

1. Create your assembly. For more information, see Creating Assemblies.

2. Assign a strong name to your assembly. For more information, see How to: Sign an Assembly with a Strong Name.

3. Assign version information to your assembly. For more information, see Assembly Versioning.

4. Add your assembly to the Global Assembly Cache. For more information, see How to: Install an Assembly into the Global Assembly Cache.

5. Access the types contained in the assembly from the other applications. For more information, see How to: Reference a Strong-Named Assembly.

See also

- C# Programming Guide
- Programming with Assemblies

Walkthrough: Embedding Types from Managed Assemblies in Visual Studio (C#)

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If you embed type information from a strong-named managed assembly, you can loosely couple types in an application to achieve version independence. That is, your program can be written to use types from multiple versions of a managed library without having to be recompiled for each version.

Type embedding is frequently used with COM interop, such as an application that uses automation objects from Microsoft Office. Embedding type information enables the same build of a program to work with different versions of Microsoft Office on different computers. However, you can also use type embedding with a fully managed solution.

Type information can be embedded from an assembly that has the following characteristics:

- The assembly exposes at least one public interface.
- The embedded interfaces are annotated with a `ComImport` attribute and a `Guid` attribute (and a unique GUID).
- The assembly is annotated with the `ImportedFromTypeLib` attribute or the `PrimaryInteropAssembly` attribute, and an assembly-level `Guid` attribute. (By default, Visual C# project templates include an assembly-level `Guid` attribute.)

After you have specified the public interfaces that can be embedded, you can create runtime classes that implement those interfaces. A client program can then embed the type information for those interfaces at design time by referencing the assembly that contains the public interfaces and setting the `Embed Interop Types` property of the reference to `True`. This is equivalent to using the command line compiler and referencing the assembly by using the `/link` compiler option. The client program can then load instances of your runtime objects typed as those interfaces. If you create a new version of your strong-named runtime assembly, the client program does not have to be recompiled with the updated runtime assembly. Instead, the client program continues to use whichever version of the runtime assembly is available to it, using the embedded type information for the public interfaces.

Because the primary function of type embedding is to support embedding of type information from COM interop assemblies, the following limitations apply when you embed type information in a fully managed solution:

- Only attributes specific to COM interop are embedded; other attributes are ignored.
- If a type uses generic parameters and the type of the generic parameter is an embedded type, that type cannot be used across an assembly boundary. Examples of crossing an assembly boundary include calling a method from another assembly or a deriving a type from a type defined in another assembly.
- Constants are not embedded.
- The System.Collections.Generic.Dictionary<TKey,TValue> class does not support an embedded type as a key. You can implement your own dictionary type to support an embedded type as a key.

In this walkthrough, you will do the following:

- Create a strong-named assembly that has a public interface that contains type information that can be embedded.
- Create a strong-named runtime assembly that implements that public interface.

- Create a client program that embeds the type information from the public interface and creates an instance of the class from the runtime assembly.
- Modify and rebuild the runtime assembly.
- Run the client program to see that the new version of the runtime assembly is being used without having to recompile the client program.

NOTE

Your computer might show different names or locations for some of the Visual Studio user interface elements in the following instructions. The Visual Studio edition that you have and the settings that you use determine these elements. For more information, see Personalizing the IDE.

Creating an Interface

To create the type equivalence interface project

1. In Visual Studio, on the **File** menu, choose **New** and then click **Project**.
2. In the **New Project** dialog box, in the **Project Types** pane, make sure that **Windows** is selected. Select **Class Library** in the **Templates** pane. In the **Name** box, type `TypeEquivalenceInterface`, and then click **OK**. The new project is created.
3. In **Solution Explorer**, right-click the Class1.cs file and click **Rename**. Rename the file to `ISampleInterface.cs` and press ENTER. Renaming the file will also rename the class to `ISampleInterface`. This class will represent the public interface for the class.
4. Right-click the TypeEquivalenceInterface project and click **Properties**. Click the **Build** tab. Set the output path to a valid location on your development computer, such as `C:\TypeEquivalenceSample`. This location will also be used in a later step in this walkthrough.
5. While still editing the project properties, click the **Signing** tab. Select the **Sign the assembly** option. In the **Choose a strong name key file** list, click **<New...>**. In the **Key file name** box, type `key.snk`. Clear the **Protect my key file with a password** check box. Click **OK**.
6. Open the ISampleInterface.cs file. Add the following code to the ISampleInterface class file to create the ISampleInterface interface.

```
using System;
using System.Runtime.InteropServices;

namespace TypeEquivalenceInterface
{
    [ComImport]
    [Guid("8DA56996-A151-4136-B474-32784559F6DF")]
    public interface ISampleInterface
    {
        void GetUserInput();
        string UserInput { get; }
 }
}
```

7. On the **Tools** menu, click **Create Guid**. In the **Create GUID** dialog box, click **Registry Format** and then click **Copy**. Click **Exit**.
8. In the `Guid` attribute, delete the sample GUID and paste in the GUID that you copied from the **Create GUID** dialog box. Remove the braces ({}) from the copied GUID.

9. In **Solution Explorer**, expand the **Properties** folder. Double-click the AssemblyInfo.cs file. Add the following attribute to the file.

   ```
   [assembly: ImportedFromTypeLib("")]
   ```

   Save the file.

10. Save the project.

11. Right-click the TypeEquivalenceInterface project and click **Build**. The class library .dll file is compiled and saved to the specified build output path (for example, C:\TypeEquivalenceSample).

Creating a Runtime Class

To create the type equivalence runtime project

1. In Visual Studio, on the **File** menu, point to **New** and then click **Project**.

2. In the **New Project** dialog box, in the **Project Types** pane, make sure that **Windows** is selected. Select **Class Library** in the **Templates** pane. In the **Name** box, type `TypeEquivalenceRuntime`, and then click **OK**. The new project is created.

3. In **Solution Explorer**, right-click the Class1.cs file and click **Rename**. Rename the file to `SampleClass.cs` and press ENTER. Renaming the file also renames the class to `SampleClass`. This class will implement the `ISampleInterface` interface.

4. Right-click the TypeEquivalenceRuntime project and click **Properties**. Click the **Build** tab. Set the output path to the same location you used in the TypeEquivalenceInterface project, for example, `C:\TypeEquivalenceSample`.

5. While still editing the project properties, click the **Signing** tab. Select the **Sign the assembly** option. In the **Choose a strong name key file** list, click **<New...>**. In the **Key file name** box, type `key.snk`. Clear the **Protect my key file with a password** check box. Click **OK**.

6. Right-click the TypeEquivalenceRuntime project and click **Add Reference**. Click the **Browse** tab and browse to the output path folder. Select the TypeEquivalenceInterface.dll file and click **OK**.

7. In **Solution Explorer**, expand the **References** folder. Select the TypeEquivalenceInterface reference. In the Properties window for the TypeEquivalenceInterface reference, set the **Specific Version** property to **False**.

8. Add the following code to the SampleClass class file to create the SampleClass class.

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using TypeEquivalenceInterface;

namespace TypeEquivalenceRuntime
{
    public class SampleClass : ISampleInterface
    {
        private string p_UserInput;
        public string UserInput { get { return p_UserInput; } }

        public void GetUserInput()
        {
            Console.WriteLine("Please enter a value:");
            p_UserInput = Console.ReadLine();
        }
    }
}
```

9. Save the project.

10. Right-click the TypeEquivalenceRuntime project and click **Build**. The class library .dll file is compiled and saved to the specified build output path (for example, C:\TypeEquivalenceSample).

Creating a Client Project

To create the type equivalence client project

1. In Visual Studio, on the **File** menu, point to **New** and then click **Project**.

2. In the **New Project** dialog box, in the **Project Types** pane, make sure that **Windows** is selected. Select **Console Application** in the **Templates** pane. In the **Name** box, type `TypeEquivalenceClient`, and then click **OK**. The new project is created.

3. Right-click the TypeEquivalenceClient project and click **Properties**. Click the **Build** tab. Set the output path to the same location you used in the TypeEquivalenceInterface project, for example, `C:\TypeEquivalenceSample`.

4. Right-click the TypeEquivalenceClient project and click **Add Reference**. Click the **Browse** tab and browse to the output path folder. Select the TypeEquivalenceInterface.dll file (not the TypeEquivalenceRuntime.dll) and click **OK**.

5. In **Solution Explorer**, expand the **References** folder. Select the TypeEquivalenceInterface reference. In the Properties window for the TypeEquivalenceInterface reference, set the **Embed Interop Types** property to **True**.

6. Add the following code to the Program.cs file to create the client program.

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using TypeEquivalenceInterface;
using System.Reflection;

namespace TypeEquivalenceClient
{
    class Program
    {
        static void Main(string[] args)
        {
            Assembly sampleAssembly = Assembly.Load("TypeEquivalenceRuntime");
            ISampleInterface sampleClass =
                (ISampleInterface)sampleAssembly.CreateInstance("TypeEquivalenceRuntime.SampleClass");
            sampleClass.GetUserInput();
            Console.WriteLine(sampleClass.UserInput);
            Console.WriteLine(sampleAssembly.GetName().Version.ToString());
            Console.ReadLine();
        }
    }
}
```

7. Press CTRL+F5 to build and run the program.

Modifying the Interface

To modify the interface

1. In Visual Studio, on the **File** menu, point to **Open**, and then click **Project/Solution**.

2. In the **Open Project** dialog box, right-click the TypeEquivalenceInterface project, and then click **Properties**. Click the **Application** tab. Click the **Assembly Information** button. Change the **Assembly Version** and **File Version** values to `2.0.0.0`.

3. Open the SampleInterface.cs file. Add the following line of code to the ISampleInterface interface.

```
DateTime GetDate();
```

   Save the file.

4. Save the project.

5. Right-click the TypeEquivalenceInterface project and click **Build**. A new version of the class library .dll file is compiled and saved in the specified build output path (for example, C:\TypeEquivalenceSample).

Modifying the Runtime Class

To modify the runtime class

1. In Visual Studio, on the **File** menu, point to **Open**, and then click **Project/Solution**.

2. In the **Open Project** dialog box, right-click the TypeEquivalenceRuntime project and click **Properties**. Click the **Application** tab. Click the **Assembly Information** button. Change the **Assembly Version** and **File Version** values to `2.0.0.0`.

3. Open the SampleClass.cs file. Add the following lines of code to the SampleClass class.

```
public DateTime GetDate()
{
    return DateTime.Now;
}
```

Save the file.

4. Save the project.

5. Right-click the TypeEquivalenceRuntime project and click **Build**. An updated version of the class library .dll file is compiled and saved in the previously specified build output path (for example, C:\TypeEquivalenceSample).

6. In File Explorer, open the output path folder (for example, C:\TypeEquivalenceSample). Double-click the TypeEquivalenceClient.exe to run the program. The program will reflect the new version of the TypeEquivalenceRuntime assembly without having been recompiled.

See also

- /link (C# Compiler Options)
- C# Programming Guide
- Programming with Assemblies
- Assemblies and the Global Assembly Cache (C#)

Walkthrough: Embedding Type Information from Microsoft Office Assemblies in Visual Studio (C#)

1/23/2019 • 3 minutes to read • Edit Online

If you embed type information in an application that references COM objects, you can eliminate the need for a primary interop assembly (PIA). Additionally, the embedded type information enables you to achieve version independence for your application. That is, your program can be written to use types from multiple versions of a COM library without requiring a specific PIA for each version. This is a common scenario for applications that use objects from Microsoft Office libraries. Embedding type information enables the same build of a program to work with different versions of Microsoft Office on different computers without the need to redeploy either the program or the PIA for each version of Microsoft Office.

NOTE

Your computer might show different names or locations for some of the Visual Studio user interface elements in the following instructions. The Visual Studio edition that you have and the settings that you use determine these elements. For more information, see Personalizing the IDE.

Prerequisites

This walkthrough requires the following:

- A computer on which Visual Studio and Microsoft Excel are installed.
- A second computer on which the .NET Framework 4 or higher and a different version of Excel are installed.

To create an application that works with multiple versions of Microsoft Office

1. Start Visual Studio on a computer on which Excel is installed.
2. On the **File** menu, choose **New**, **Project**.
3. In the **New Project** dialog box, in the **Project Types** pane, make sure that **Windows** is selected. Select **Console Application** in the **Templates** pane. In the **Name** box, enter `CreateExcelWorkbook`, and then choose the **OK** button. The new project is created.
4. In **Solution Explorer**, open the shortcut menu for the **References** folder and then choose **Add Reference**.
5. On the **.NET** tab, choose the most recent version of `Microsoft.Office.Interop.Excel`. For example, **Microsoft.Office.Interop.Excel 14.0.0.0**. Choose the **OK** button.
6. In the list of references for the **CreateExcelWorkbook** project, select the reference for `Microsoft.Office.Interop.Excel` that you added in the previous step. In the **Properties** window, make sure that the `Embed Interop Types` property is set to `True`.

NOTE

The application created in this walkthrough runs with different versions of Microsoft Office because of the embedded interop type information. If the `Embed Interop Types` property is set to `False`, you must include a PIA for each version of Microsoft Office that the application will run with.

7. Open the **Program.cs** file. Replace the code in the file with the following code:

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.IO;
using Excel = Microsoft.Office.Interop.Excel;

namespace CreateExcelWorkbook
{
    class Program
    {
        static void Main(string[] args)
        {
            int[] values = {4, 6, 18, 2, 1, 76, 0, 3, 11};

            CreateWorkbook(values, @"C:\SampleFolder\SampleWorkbook.xls");
        }

        static void CreateWorkbook(int[] values, string filePath)
        {
            Excel.Application excelApp = null;
            Excel.Workbook wkbk;
            Excel.Worksheet sheet;

            try
            {
                    // Start Excel and create a workbook and worksheet.
                    excelApp = new Excel.Application();
                    wkbk = excelApp.Workbooks.Add();
                    sheet = wkbk.Sheets.Add() as Excel.Worksheet;
                    sheet.Name = "Sample Worksheet";

                    // Write a column of values.
                    // In the For loop, both the row index and array index start at 1.
                    // Therefore the value of 4 at array index 0 is not included.
                    for (int i = 1; i < values.Length; i++)
                    {
                        sheet.Cells[i, 1] = values[i];
                    }

                    // Suppress any alerts and save the file. Create the directory
                    // if it does not exist. Overwrite the file if it exists.
                    excelApp.DisplayAlerts = false;
                    string folderPath = Path.GetDirectoryName(filePath);
                    if (!Directory.Exists(folderPath))
                    {
                        Directory.CreateDirectory(folderPath);
                    }
                    wkbk.SaveAs(filePath);
            }
            catch
            {
            }
            finally
            {
                sheet = null;
                wkbk = null;

                // Close Excel.
                excelApp.Quit();
                excelApp = null;
            }
        }
    }
}
```

8. Save the project.

9. Press CTRL+F5 to build and run the project. Verify that an Excel workbook has been created at the location specified in the example code: C:\SampleFolder\SampleWorkbook.xls.

To publish the application to a computer on which a different version of Microsoft Office is installed

1. Open the project created by this walkthrough in Visual Studio.

2. On the **Build** menu, choose **Publish CreateExcelWorkbook**. Follow the steps of the Publish Wizard to create an installable version of the application. For more information, see Publish Wizard (Office Development in Visual Studio).

3. Install the application on a computer on which the .NET Framework 4 or higher and a different version of Excel are installed.

4. When the installation is finished, run the installed program.

5. Verify that an Excel workbook has been created at the location specified in the sample code: C:\SampleFolder\SampleWorkbook.xls.

See also

- Walkthrough: Embedding Types from Managed Assemblies in Visual Studio (C#)
- /link (C# Compiler Options)

Contents

Attributes (C#)

1/23/2019 • 5 minutes to read • Edit Online

Attributes provide a powerful method of associating metadata, or declarative information, with code (assemblies, types, methods, properties, and so forth). After an attribute is associated with a program entity, the attribute can be queried at run time by using a technique called *reflection*. For more information, see Reflection (C#).

Attributes have the following properties:

- Attributes add metadata to your program. *Metadata* is information about the types defined in a program. All .NET assemblies contain a specified set of metadata that describes the types and type members defined in the assembly. You can add custom attributes to specify any additional information that is required. For more information, see, Creating Custom Attributes (C#).
- You can apply one or more attributes to entire assemblies, modules, or smaller program elements such as classes and properties.
- Attributes can accept arguments in the same way as methods and properties.
- Your program can examine its own metadata or the metadata in other programs by using reflection. For more information, see Accessing Attributes by Using Reflection (C#).

Using attributes

Attributes can be placed on most any declaration, though a specific attribute might restrict the types of declarations on which it is valid. In C#, you specify an attribute by placing the name of the attribute enclosed in square brackets ([]) above the declaration of the entity to which it applies.

In this example, the SerializableAttribute attribute is used to apply a specific characteristic to a class:

```
[Serializable]
public class SampleClass
{
    // Objects of this type can be serialized.
}
```

A method with the attribute DllImportAttribute is declared like the following example:

```
[System.Runtime.InteropServices.DllImport("user32.dll")]
extern static void SampleMethod();
```

More than one attribute can be placed on a declaration as the following example shows:

```
using System.Runtime.InteropServices;
```

```
void MethodA([In][Out] ref double x) { }
void MethodB([Out][In] ref double x) { }
void MethodC([In, Out] ref double x) { }
```

Some attributes can be specified more than once for a given entity. An example of such a multiuse attribute is ConditionalAttribute:

```
[Conditional("DEBUG"), Conditional("TEST1")]
void TraceMethod()
{
    // ...
}
```

NOTE

By convention, all attribute names end with the word "Attribute" to distinguish them from other items in the .NET libraries. However, you do not need to specify the attribute suffix when using attributes in code. For example, `[DllImport]` is equivalent to `[DllImportAttribute]`, but `DllImportAttribute` is the attribute's actual name in the .NET Framework Class Library.

Attribute parameters

Many attributes have parameters, which can be positional, unnamed, or named. Any positional parameters must be specified in a certain order and cannot be omitted. Named parameters are optional and can be specified in any order. Positional parameters are specified first. For example, these three attributes are equivalent:

```
[DllImport("user32.dll")]
[DllImport("user32.dll", SetLastError=false, ExactSpelling=false)]
[DllImport("user32.dll", ExactSpelling=false, SetLastError=false)]
```

The first parameter, the DLL name, is positional and always comes first; the others are named. In this case, both named parameters default to false, so they can be omitted. Positional parameters correspond to the parameters of the attribute constructor. Named or optional parameters correspond to either properties or fields of the attribute. Refer to the individual attribute's documentation for information on default parameter values.

Attribute targets

The *target* of an attribute is the entity to which the attribute applies. For example, an attribute may apply to a class, a particular method, or an entire assembly. By default, an attribute applies to the element that it precedes. But you can also explicitly identify, for example, whether an attribute is applied to a method, or to its parameter, or to its return value.

To explicitly identify an attribute target, use the following syntax:

```
[target : attribute-list]
```

The list of possible `target` values is shown in the following table.

TARGET VALUE	APPLIES TO
`assembly`	Entire assembly
`module`	Current assembly module
`field`	Field in a class or a struct
`event`	Event
`method`	Method or `get` and `set` property accessors

TARGET VALUE	APPLIES TO
`param`	Method parameters or `set` property accessor parameters
`property`	Property
`return`	Return value of a method, property indexer, or `get` property accessor
`type`	Struct, class, interface, enum, or delegate

You would specify the `field` target value to apply an attribute to the backing field created for an auto-implemented property.

The following example shows how to apply attributes to assemblies and modules. For more information, see Common Attributes (C#).

```
using System;
using System.Reflection;
[assembly: AssemblyTitleAttribute("Production assembly 4")]
[module: CLSCompliant(true)]
```

The following example shows how to apply attributes to methods, method parameters, and method return values in C#.

```
// default: applies to method
[ValidatedContract]
int Method1() { return 0; }

// applies to method
[method: ValidatedContract]
int Method2() { return 0; }

// applies to return value
[return: ValidatedContract]
int Method3() { return 0; }
```

NOTE

Regardless of the targets on which `ValidatedContract` is defined to be valid, the `return` target has to be specified, even if `ValidatedContract` were defined to apply only to return values. In other words, the compiler will not use `AttributeUsage` information to resolve ambiguous attribute targets. For more information, see AttributeUsage (C#).

Common uses for attributes

The following list includes a few of the common uses of attributes in code:

- Marking methods using the `WebMethod` attribute in Web services to indicate that the method should be callable over the SOAP protocol. For more information, see WebMethodAttribute.
- Describing how to marshal method parameters when interoperating with native code. For more information, see MarshalAsAttribute.
- Describing the COM properties for classes, methods, and interfaces.
- Calling unmanaged code using the DllImportAttribute class.
- Describing your assembly in terms of title, version, description, or trademark.

- Describing which members of a class to serialize for persistence.
- Describing how to map between class members and XML nodes for XML serialization.
- Describing the security requirements for methods.
- Specifying characteristics used to enforce security.
- Controlling optimizations by the just-in-time (JIT) compiler so the code remains easy to debug.
- Obtaining information about the caller to a method.

Related sections

For more information, see:

- Creating Custom Attributes (C#)
- Accessing Attributes by Using Reflection (C#)
- How to: Create a C/C++ Union by Using Attributes (C#)
- Common Attributes (C#)
- Caller Information (C#)

See also

- C# Programming Guide
- Reflection (C#)
- Attributes
- Using Attributes in C#

Creating Custom Attributes (C#)

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You can create your own custom attributes by defining an attribute class, a class that derives directly or indirectly from Attribute, which makes identifying attribute definitions in metadata fast and easy. Suppose you want to tag types with the name of the programmer who wrote the type. You might define a custom `Author` attribute class:

```
[System.AttributeUsage(System.AttributeTargets.Class |
                       System.AttributeTargets.Struct)
]
public class Author : System.Attribute
{
    private string name;
    public double version;

    public Author(string name)
    {
        this.name = name;
        version = 1.0;
    }
}
```

The class name is the attribute's name, `Author`. It is derived from `System.Attribute`, so it is a custom attribute class. The constructor's parameters are the custom attribute's positional parameters. In this example, `name` is a positional parameter. Any public read-write fields or properties are named parameters. In this case, `version` is the only named parameter. Note the use of the `AttributeUsage` attribute to make the `Author` attribute valid only on class and `struct` declarations.

You could use this new attribute as follows:

```
[Author("P. Ackerman", version = 1.1)]
class SampleClass
{
    // P. Ackerman's code goes here...
}
```

`AttributeUsage` has a named parameter, `AllowMultiple`, with which you can make a custom attribute single-use or multiuse. In the following code example, a multiuse attribute is created.

```
[System.AttributeUsage(System.AttributeTargets.Class |
                       System.AttributeTargets.Struct,
                       AllowMultiple = true)  // multiuse attribute
]
public class Author : System.Attribute
```

In the following code example, multiple attributes of the same type are applied to a class.

```
[Author("P. Ackerman", version = 1.1)]
[Author("R. Koch", version = 1.2)]
class SampleClass
{
    // P. Ackerman's code goes here...
    // R. Koch's code goes here...
}
```

See also

- System.Reflection
- C# Programming Guide
- Writing Custom Attributes
- Reflection (C#)
- Attributes (C#)
- Accessing Attributes by Using Reflection (C#)
- AttributeUsage (C#)

AttributeUsage (C#)

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Determines how a custom attribute class can be used. AttributeUsageAttribute is an attribute you apply to custom attribute definitions. The `AttributeUsage` attribute enables you to control:

- Which program elements attribute may be applied to. Unless you restrict its usage, an attribute may be applied to any of the following program elements:
  - assembly
  - module
  - field
  - event
  - method
  - param
  - property
  - return
  - type
- Whether an attribute can be applied to a single program element multiple times.
- Whether attributes are inherited by derived classes.

The default settings look like the following example when applied explicitly:

```
[System.AttributeUsage(System.AttributeTargets.All,
                   AllowMultiple = false,
                   Inherited = true)]
class NewAttribute : System.Attribute { }
```

In this example, the `NewAttribute` class can be applied to any supported program element. But it can be applied only once to each entity. The attribute is inherited by derived classes when applied to a base class.

The AllowMultiple and Inherited arguments are optional, so the following code has the same effect:

```
[System.AttributeUsage(System.AttributeTargets.All)]
class NewAttribute : System.Attribute { }
```

The first AttributeUsageAttribute argument must be one or more elements of the AttributeTargets enumeration. Multiple target types can be linked together with the OR operator, like the following example shows:

```
[AttributeUsage(AttributeTargets.Property | AttributeTargets.Field)]
class NewPropertyOrFieldAttribute : Attribute { }
```

Beginning in C# 7.3, attributes can be applied to either the property or the backing field for an auto-implemented property. The attribute applies to the property, unless you specify the `field` specifier on the attribute. Both are shown in the following example:

```
class MyClass
{
    // Attribute attached to property:
    [NewPropertyOrField]
    public string Name { get; set; }

    // Attribute attached to backing field:
    [field:NewPropertyOrField]
    public string Description { get; set; }
}
```

If the AllowMultiple argument is `true`, then the resulting attribute can be applied more than once to a single entity, as shown in the following example:

```
[AttributeUsage(AttributeTargets.Class, AllowMultiple = true)]
class MultiUse : Attribute { }

[MultiUse]
[MultiUse]
class Class1 { }

[MultiUse, MultiUse]
class Class2 { }
```

In this case, `MultiUseAttribute` can be applied repeatedly because `AllowMultiple` is set to `true`. Both formats shown for applying multiple attributes are valid.

If Inherited is `false`, then the attribute isn't inherited by classes derived from an attributed class. For example:

```
[AttributeUsage(AttributeTargets.Class, Inherited = false)]
class NonInheritedAttribute : Attribute { }

[NonInherited]
class BClass { }

class DClass : BClass { }
```

In this case `NonInheritedAttribute` isn't applied to `DClass` via inheritance.

Remarks

The `AttributeUsage` attribute is a single-use attribute--it can't be applied more than once to the same class. `AttributeUsage` is an alias for AttributeUsageAttribute.

For more information, see Accessing Attributes by Using Reflection (C#).

Example

The following example demonstrates the effect of the Inherited and AllowMultiple arguments to the AttributeUsageAttribute attribute, and how the custom attributes applied to a class can be enumerated.

```
using System;

// Create some custom attributes:
[AttributeUsage(AttributeTargets.Class, Inherited = false)]
class FirstAttribute : Attribute { }

[AttributeUsage(AttributeTargets.Class)]
class SecondAttribute : Attribute { }

[AttributeUsage(AttributeTargets.Class, AllowMultiple = true)]
class ThirdAttribute : Attribute { }

// Apply custom attributes to classes:
[First, Second]
class BaseClass { }

[Third, Third]
class DerivedClass : BaseClass { }

public class TestAttributeUsage
{
    static void Main()
    {
        BaseClass b = new BaseClass();
        DerivedClass d = new DerivedClass();

        // Display custom attributes for each class.
        Console.WriteLine("Attributes on Base Class:");
        object[] attrs = b.GetType().GetCustomAttributes(true);
        foreach (Attribute attr in attrs)
        {
            Console.WriteLine(attr);
        }

        Console.WriteLine("Attributes on Derived Class:");
        attrs = d.GetType().GetCustomAttributes(true);
        foreach (Attribute attr in attrs)
        {
            Console.WriteLine(attr);
        }
    }
}
```

Sample Output

```
Attributes on Base Class:
FirstAttribute
SecondAttribute
Attributes on Derived Class:
ThirdAttribute
ThirdAttribute
SecondAttribute
```

See also

- Attribute
- System.Reflection
- C# Programming Guide
- Attributes
- Reflection (C#)

- Attributes
- Creating Custom Attributes (C#)
- Accessing Attributes by Using Reflection (C#)

Accessing Attributes by Using Reflection (C#)

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The fact that you can define custom attributes and place them in your source code would be of little value without some way of retrieving that information and acting on it. By using reflection, you can retrieve the information that was defined with custom attributes. The key method is `GetCustomAttributes`, which returns an array of objects that are the run-time equivalents of the source code attributes. This method has several overloaded versions. For more information, see Attribute.

An attribute specification such as:

```
[Author("P. Ackerman", version = 1.1)]
class SampleClass
```

is conceptually equivalent to this:

```
Author anonymousAuthorObject = new Author("P. Ackerman");
anonymousAuthorObject.version = 1.1;
```

However, the code is not executed until `SampleClass` is queried for attributes. Calling `GetCustomAttributes` on `SampleClass` causes an `Author` object to be constructed and initialized as above. If the class has other attributes, other attribute objects are constructed similarly. `GetCustomAttributes` then returns the `Author` object and any other attribute objects in an array. You can then iterate over this array, determine what attributes were applied based on the type of each array element, and extract information from the attribute objects.

Example

Here is a complete example. A custom attribute is defined, applied to several entities, and retrieved via reflection.

```
// Multiuse attribute.
[System.AttributeUsage(System.AttributeTargets.Class |
                       System.AttributeTargets.Struct,
                       AllowMultiple = true)  // Multiuse attribute.
]
public class Author : System.Attribute
{
    string name;
    public double version;

    public Author(string name)
    {
        this.name = name;

        // Default value.
        version = 1.0;
    }

    public string GetName()
    {
        return name;
    }
}

// Class with the Author attribute.
[Author("P. Ackerman")]
```

```
public class FirstClass
{
    // ...
}

// Class without the Author attribute.
public class SecondClass
{
    // ...
}

// Class with multiple Author attributes.
[Author("P. Ackerman"), Author("R. Koch", version = 2.0)]
public class ThirdClass
{
    // ...
}

class TestAuthorAttribute
{
    static void Test()
    {
        PrintAuthorInfo(typeof(FirstClass));
        PrintAuthorInfo(typeof(SecondClass));
        PrintAuthorInfo(typeof(ThirdClass));
    }

    private static void PrintAuthorInfo(System.Type t)
    {
        System.Console.WriteLine("Author information for {0}", t);

        // Using reflection.
        System.Attribute[] attrs = System.Attribute.GetCustomAttributes(t);  // Reflection.

        // Displaying output.
        foreach (System.Attribute attr in attrs)
        {
            if (attr is Author)
            {
                Author a = (Author)attr;
                System.Console.WriteLine("   {0}, version {1:f}", a.GetName(), a.version);
            }
        }
    }
}
/* Output:
    Author information for FirstClass
       P. Ackerman, version 1.00
    Author information for SecondClass
    Author information for ThirdClass
       R. Koch, version 2.00
       P. Ackerman, version 1.00
*/
```

See also

- System.Reflection
- Attribute
- C# Programming Guide
- Retrieving Information Stored in Attributes
- Reflection (C#)
- Attributes (C#)
- Creating Custom Attributes (C#)

How to: Create a C/C++ Union by Using Attributes (C#)

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By using attributes you can customize how structs are laid out in memory. For example, you can create what is known as a union in C/C++ by using the `StructLayout(LayoutKind.Explicit)` and `FieldOffset` attributes.

Example

In this code segment, all of the fields of `TestUnion` start at the same location in memory.

```
// Add a using directive for System.Runtime.InteropServices.

        [System.Runtime.InteropServices.StructLayout(LayoutKind.Explicit)]
        struct TestUnion
        {
            [System.Runtime.InteropServices.FieldOffset(0)]
            public int i;

            [System.Runtime.InteropServices.FieldOffset(0)]
            public double d;

            [System.Runtime.InteropServices.FieldOffset(0)]
            public char c;

            [System.Runtime.InteropServices.FieldOffset(0)]
            public byte b;
        }
```

Example

The following is another example where fields start at different explicitly set locations.

```
// Add a using directive for System.Runtime.InteropServices.

       [System.Runtime.InteropServices.StructLayout(LayoutKind.Explicit)]
       struct TestExplicit
       {
           [System.Runtime.InteropServices.FieldOffset(0)]
           public long lg;

           [System.Runtime.InteropServices.FieldOffset(0)]
           public int i1;

           [System.Runtime.InteropServices.FieldOffset(4)]
           public int i2;

           [System.Runtime.InteropServices.FieldOffset(8)]
           public double d;

           [System.Runtime.InteropServices.FieldOffset(12)]
           public char c;

           [System.Runtime.InteropServices.FieldOffset(14)]
           public byte b;
       }
```

The two integer fields, `i1` and `i2`, share the same memory locations as `lg`. This sort of control over struct layout is useful when using platform invocation.

See also

- System.Reflection
- Attribute
- C# Programming Guide
- Attributes
- Reflection (C#)
- Attributes (C#)
- Creating Custom Attributes (C#)
- Accessing Attributes by Using Reflection (C#)

Common Attributes (C#)

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This topic describes the attributes that are most commonly used in C# programs.

- Global Attributes
- Obsolete Attribute
- Conditional Attribute
- Caller Info Attributes

Global Attributes

Most attributes are applied to specific language elements such as classes or methods; however, some attributes are global—they apply to an entire assembly or module. For example, the AssemblyVersionAttribute attribute can be used to embed version information into an assembly, like this:

```
[assembly: AssemblyVersion("1.0.0.0")]
```

Global attributes appear in the source code after any top-level `using` directives and before any type, module, or namespace declarations. Global attributes can appear in multiple source files, but the files must be compiled in a single compilation pass. In C# projects, global attributes are put in the AssemblyInfo.cs file.

Assembly attributes are values that provide information about an assembly. They fall into the following categories:

- Assembly identity attributes
- Informational attributes
- Assembly manifest attributes

Assembly Identity Attributes

Three attributes (with a strong name, if applicable) determine the identity of an assembly: name, version, and culture. These attributes form the full name of the assembly and are required when you reference it in code. You can set an assembly's version and culture using attributes. However, the name value is set by the compiler, the Visual Studio IDE in the Assembly Information Dialog Box, or the Assembly Linker (Al.exe) when the assembly is created, based on the file that contains the assembly manifest. The AssemblyFlagsAttribute attribute specifies whether multiple copies of the assembly can coexist.

The following table shows the identity attributes.

ATTRIBUTE	PURPOSE
AssemblyName	Fully describes the identity of an assembly.
AssemblyVersionAttribute	Specifies the version of an assembly.
AssemblyCultureAttribute	Specifies which culture the assembly supports.

ATTRIBUTE	PURPOSE
AssemblyFlagsAttribute	Specifies whether an assembly supports side-by-side execution on the same computer, in the same process, or in the same application domain.

Informational Attributes

You can use informational attributes to provide additional company or product information for an assembly. The following table shows the informational attributes defined in the System.Reflection namespace.

ATTRIBUTE	PURPOSE
AssemblyProductAttribute	Defines a custom attribute that specifies a product name for an assembly manifest.
AssemblyTrademarkAttribute	Defines a custom attribute that specifies a trademark for an assembly manifest.
AssemblyInformationalVersionAttribute	Defines a custom attribute that specifies an informational version for an assembly manifest.
AssemblyCompanyAttribute	Defines a custom attribute that specifies a company name for an assembly manifest.
AssemblyCopyrightAttribute	Defines a custom attribute that specifies a copyright for an assembly manifest.
AssemblyFileVersionAttribute	Instructs the compiler to use a specific version number for the Win32 file version resource.
CLSCompliantAttribute	Indicates whether the assembly is compliant with the Common Language Specification (CLS).

Assembly Manifest Attributes

You can use assembly manifest attributes to provide information in the assembly manifest. This includes title, description, default alias, and configuration. The following table shows the assembly manifest attributes defined in the System.Reflection namespace.

ATTRIBUTE	PURPOSE
AssemblyTitleAttribute	Defines a custom attribute that specifies an assembly title for an assembly manifest.
AssemblyDescriptionAttribute	Defines a custom attribute that specifies an assembly description for an assembly manifest.
AssemblyConfigurationAttribute	Defines a custom attribute that specifies an assembly configuration (such as retail or debug) for an assembly manifest.
AssemblyDefaultAliasAttribute	Defines a friendly default alias for an assembly manifest

Obsolete Attribute

The `Obsolete` attribute marks a program entity as one that is no longer recommended for use. Each use of an entity marked obsolete will subsequently generate a warning or an error, depending on how the attribute is configured. For example:

```
[System.Obsolete("use class B")]
class A
{
    public void Method() { }
}
class B
{
    [System.Obsolete("use NewMethod", true)]
    public void OldMethod() { }
    public void NewMethod() { }
}
```

In this example the `Obsolete` attribute is applied to class `A` and to method `B.OldMethod`. Because the second argument of the attribute constructor applied to `B.OldMethod` is set to `true`, this method will cause a compiler error, whereas using class `A` will just produce a warning. Calling `B.NewMethod`, however, produces no warning or error.

The string provided as the first argument to attribute constructor will be displayed as part of the warning or error. For example, when you use it with the previous definitions, the following code generates two warnings and one error:

```
// Generates 2 warnings:
// A a = new A();

// Generate no errors or warnings:
B b = new B();
b.NewMethod();

// Generates an error, terminating compilation:
// b.OldMethod();
```

Two warnings for class `A` are generated: one for the declaration of the class reference, and one for the class constructor.

The `Obsolete` attribute can be used without arguments, but including an explanation of why the item is obsolete and what to use instead is recommended.

The `Obsolete` attribute is a single-use attribute and can be applied to any entity that allows attributes. `Obsolete` is an alias for ObsoleteAttribute.

Conditional Attribute

The `Conditional` attribute makes the execution of a method dependent on a preprocessing identifier. The `Conditional` attribute is an alias for ConditionalAttribute, and can be applied to a method or an attribute class.

In this example, `Conditional` is applied to a method to enable or disable the display of program-specific diagnostic information:

```
#define TRACE_ON
using System;
using System.Diagnostics;

public class Trace
{
    [Conditional("TRACE_ON")]
    public static void Msg(string msg)
    {
        Console.WriteLine(msg);
    }
}

public class ProgramClass
{
    static void Main()
    {
        Trace.Msg("Now in Main...");
        Console.WriteLine("Done.");
    }
}
```

If the `TRACE_ON` identifier is not defined, no trace output will be displayed.

The `Conditional` attribute is often used with the `DEBUG` identifier to enable trace and logging features for debug builds but not in release builds, like this:

```
[Conditional("DEBUG")]
static void DebugMethod()
{
}
```

When a method marked as conditional is called, the presence or absence of the specified preprocessing symbol determines whether the call is included or omitted. If the symbol is defined, the call is included; otherwise, the call is omitted. Using `Conditional` is a cleaner, more elegant, and less error-prone alternative to enclosing methods inside `#if…#endif` blocks, like this:

```
#if DEBUG
    void ConditionalMethod()
    {
    }
#endif
```

A conditional method must be a method in a class or struct declaration and must not have a return value.

Using Multiple Identifiers

If a method has multiple `Conditional` attributes, a call to the method is included if at least one of the conditional symbols is defined (in other words, the symbols are logically linked together by using the OR operator). In this example, the presence of either `A` or `B` will result in a method call:

```
[Conditional("A"), Conditional("B")]
static void DoIfAorB()
{
    // ...
}
```

To achieve the effect of logically linking symbols by using the AND operator, you can define serial conditional methods. For example, the second method below will execute only if both `A` and `B` are defined:

```
[Conditional("A")]
static void DoIfA()
{
    DoIfAandB();
}

[Conditional("B")]
static void DoIfAandB()
{
    // Code to execute when both A and B are defined...
}
```

Using Conditional with Attribute Classes

The `Conditional` attribute can also be applied to an attribute class definition. In this example, the custom attribute `Documentation` will only add information to the metadata if DEBUG is defined.

```
[Conditional("DEBUG")]
public class Documentation : System.Attribute
{
    string text;

    public Documentation(string text)
    {
        this.text = text;
    }
}

class SampleClass
{
    // This attribute will only be included if DEBUG is defined.
    [Documentation("This method displays an integer.")]
    static void DoWork(int i)
    {
        System.Console.WriteLine(i.ToString());
    }
}
```

Caller Info Attributes

By using Caller Info attributes, you can obtain information about the caller to a method. You can obtain the file path of the source code, the line number in the source code, and the member name of the caller.

To obtain member caller information, you use attributes that are applied to optional parameters. Each optional parameter specifies a default value. The following table lists the Caller Info attributes that are defined in the System.Runtime.CompilerServices namespace:

ATTRIBUTE	DESCRIPTION	TYPE
CallerFilePathAttribute	Full path of the source file that contains the caller. This is the path at compile time.	`String`
CallerLineNumberAttribute	Line number in the source file from which the method is called.	`Integer`
CallerMemberNameAttribute	Method name or property name of the caller. For more information, see Caller Information (C#).	`String`

For more information about the Caller Info attributes, see Caller Information (C#).

See also

- System.Reflection
- Attribute
- C# Programming Guide
- Attributes
- Reflection (C#)
- Accessing Attributes by Using Reflection (C#)

Contents

Covariance and Contravariance (C#)

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In C#, covariance and contravariance enable implicit reference conversion for array types, delegate types, and generic type arguments. Covariance preserves assignment compatibility and contravariance reverses it.

The following code demonstrates the difference between assignment compatibility, covariance, and contravariance.

```
// Assignment compatibility.
string str = "test";
// An object of a more derived type is assigned to an object of a less derived type.
object obj = str;

// Covariance.
IEnumerable<string> strings = new List<string>();
// An object that is instantiated with a more derived type argument
// is assigned to an object instantiated with a less derived type argument.
// Assignment compatibility is preserved.
IEnumerable<object> objects = strings;

// Contravariance.
// Assume that the following method is in the class:
// static void SetObject(object o) { }
Action<object> actObject = SetObject;
// An object that is instantiated with a less derived type argument
// is assigned to an object instantiated with a more derived type argument.
// Assignment compatibility is reversed.
Action<string> actString = actObject;
```

Covariance for arrays enables implicit conversion of an array of a more derived type to an array of a less derived type. But this operation is not type safe, as shown in the following code example.

```
object[] array = new String[10];
// The following statement produces a run-time exception.
// array[0] = 10;
```

Covariance and contravariance support for method groups allows for matching method signatures with delegate types. This enables you to assign to delegates not only methods that have matching signatures, but also methods that return more derived types (covariance) or that accept parameters that have less derived types (contravariance) than that specified by the delegate type. For more information, see Variance in Delegates (C#) and Using Variance in Delegates (C#).

The following code example shows covariance and contravariance support for method groups.

```
static object GetObject() { return null; }
static void SetObject(object obj) { }

static string GetString() { return ""; }
static void SetString(string str) { }

static void Test()
{
    // Covariance. A delegate specifies a return type as object,
    // but you can assign a method that returns a string.
    Func<object> del = GetString;

    // Contravariance. A delegate specifies a parameter type as string,
    // but you can assign a method that takes an object.
    Action<string> del2 = SetObject;
}
```

In .NET Framework 4 or newer C# supports covariance and contravariance in generic interfaces and delegates and allows for implicit conversion of generic type parameters. For more information, see Variance in Generic Interfaces (C#) and Variance in Delegates (C#).

The following code example shows implicit reference conversion for generic interfaces.

```
IEnumerable<String> strings = new List<String>();
IEnumerable<Object> objects = strings;
```

A generic interface or delegate is called *variant* if its generic parameters are declared covariant or contravariant. C# enables you to create your own variant interfaces and delegates. For more information, see Creating Variant Generic Interfaces (C#) and Variance in Delegates (C#).

Related Topics

TITLE	DESCRIPTION
Variance in Generic Interfaces (C#)	Discusses covariance and contravariance in generic interfaces and provides a list of variant generic interfaces in the .NET Framework.
Creating Variant Generic Interfaces (C#)	Shows how to create custom variant interfaces.
Using Variance in Interfaces for Generic Collections (C#)	Shows how covariance and contravariance support in the IEnumerable<T> and IComparable<T> interfaces can help you reuse code.
Variance in Delegates (C#)	Discusses covariance and contravariance in generic and non-generic delegates and provides a list of variant generic delegates in the .NET Framework.
Using Variance in Delegates (C#)	Shows how to use covariance and contravariance support in non-generic delegates to match method signatures with delegate types.
Using Variance for Func and Action Generic Delegates (C#)	Shows how covariance and contravariance support in the `Func` and `Action` delegates can help you reuse code.

Variance in Generic Interfaces (C#)

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.NET Framework 4 introduced variance support for several existing generic interfaces. Variance support enables implicit conversion of classes that implement these interfaces. The following interfaces are now variant:

- IEnumerable<T> (T is covariant)
- IEnumerator<T> (T is covariant)
- IQueryable<T> (T is covariant)
- IGrouping<TKey,TElement> (`TKey` and `TElement` are covariant)
- IComparer<T> (T is contravariant)
- IEqualityComparer<T> (T is contravariant)
- IComparable<T> (T is contravariant)

Covariance permits a method to have a more derived return type than that defined by the generic type parameter of the interface. To illustrate the covariance feature, consider these generic interfaces: `IEnumerable<Object>` and `IEnumerable<String>`. The `IEnumerable<String>` interface does not inherit the `IEnumerable<Object>` interface. However, the `String` type does inherit the `Object` type, and in some cases you may want to assign objects of these interfaces to each other. This is shown in the following code example.

```
IEnumerable<String> strings = new List<String>();
IEnumerable<Object> objects = strings;
```

In earlier versions of the .NET Framework, this code causes a compilation error in C# with `Option Strict On`. But now you can use `strings` instead of `objects`, as shown in the previous example, because the IEnumerable<T> interface is covariant.

Contravariance permits a method to have argument types that are less derived than that specified by the generic parameter of the interface. To illustrate contravariance, assume that you have created a `BaseComparer` class to compare instances of the `BaseClass` class. The `BaseComparer` class implements the `IEqualityComparer<BaseClass>` interface. Because the IEqualityComparer<T> interface is now contravariant, you can use `BaseComparer` to compare instances of classes that inherit the `BaseClass` class. This is shown in the following code example.

```
// Simple hierarchy of classes.
class BaseClass { }
class DerivedClass : BaseClass { }

// Comparer class.
class BaseComparer : IEqualityComparer<BaseClass>
{
    public int GetHashCode(BaseClass baseInstance)
    {
        return baseInstance.GetHashCode();
    }
    public bool Equals(BaseClass x, BaseClass y)
    {
        return x == y;
    }
}
class Program
{
    static void Test()
    {
        IEqualityComparer<BaseClass> baseComparer = new BaseComparer();

        // Implicit conversion of IEqualityComparer<BaseClass> to
        // IEqualityComparer<DerivedClass>.
        IEqualityComparer<DerivedClass> childComparer = baseComparer;
    }
}
```

For more examples, see Using Variance in Interfaces for Generic Collections (C#).

Variance in generic interfaces is supported for reference types only. Value types do not support variance. For example, `IEnumerable<int>` cannot be implicitly converted to `IEnumerable<object>`, because integers are represented by a value type.

```
IEnumerable<int> integers = new List<int>();
// The following statement generates a compiler errror,
// because int is a value type.
// IEnumerable<Object> objects = integers;
```

It is also important to remember that classes that implement variant interfaces are still invariant. For example, although List<T> implements the covariant interface IEnumerable<T>, you cannot implicitly convert `List<Object>` to `List<String>`. This is illustrated in the following code example.

```
// The following line generates a compiler error
// because classes are invariant.
// List<Object> list = new List<String>();

// You can use the interface object instead.
IEnumerable<Object> listObjects = new List<String>();
```

See also

- Using Variance in Interfaces for Generic Collections (C#)
- Creating Variant Generic Interfaces (C#)
- Generic Interfaces
- Variance in Delegates (C#)

Creating Variant Generic Interfaces (C#)

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You can declare generic type parameters in interfaces as covariant or contravariant. *Covariance* allows interface methods to have more derived return types than that defined by the generic type parameters. *Contravariance* allows interface methods to have argument types that are less derived than that specified by the generic parameters. A generic interface that has covariant or contravariant generic type parameters is called *variant*.

NOTE

.NET Framework 4 introduced variance support for several existing generic interfaces. For the list of the variant interfaces in the .NET Framework, see Variance in Generic Interfaces (C#).

Declaring Variant Generic Interfaces

You can declare variant generic interfaces by using the `in` and `out` keywords for generic type parameters.

IMPORTANT

`ref`, `in`, and `out` parameters in C# cannot be variant. Value types also do not support variance.

You can declare a generic type parameter covariant by using the `out` keyword. The covariant type must satisfy the following conditions:

- The type is used only as a return type of interface methods and not used as a type of method arguments. This is illustrated in the following example, in which the type `R` is declared covariant.

  ```
  interface ICovariant<out R>
  {
      R GetSomething();
      // The following statement generates a compiler error.
      // void SetSometing(R sampleArg);

  }
  ```

  There is one exception to this rule. If you have a contravariant generic delegate as a method parameter, you can use the type as a generic type parameter for the delegate. This is illustrated by the type `R` in the following example. For more information, see Variance in Delegates (C#) and Using Variance for Func and Action Generic Delegates (C#).

  ```
  interface ICovariant<out R>
  {
      void DoSomething(Action<R> callback);
  }
  ```

- The type is not used as a generic constraint for the interface methods. This is illustrated in the following code.

```
interface ICovariant<out R>
{
    // The following statement generates a compiler error
    // because you can use only contravariant or invariant types
    // in generic contstraints.
    // void DoSomething<T>() where T : R;
}
```

You can declare a generic type parameter contravariant by using the `in` keyword. The contravariant type can be used only as a type of method arguments and not as a return type of interface methods. The contravariant type can also be used for generic constraints. The following code shows how to declare a contravariant interface and use a generic constraint for one of its methods.

```
interface IContravariant<in A>
{
    void SetSomething(A sampleArg);
    void DoSomething<T>() where T : A;
    // The following statement generates a compiler error.
    // A GetSomething();
}
```

It is also possible to support both covariance and contravariance in the same interface, but for different type parameters, as shown in the following code example.

```
interface IVariant<out R, in A>
{
    R GetSomething();
    void SetSomething(A sampleArg);
    R GetSetSometings(A sampleArg);
}
```

Implementing Variant Generic Interfaces

You implement variant generic interfaces in classes by using the same syntax that is used for invariant interfaces. The following code example shows how to implement a covariant interface in a generic class.

```
interface ICovariant<out R>
{
    R GetSomething();
}
class SampleImplementation<R> : ICovariant<R>
{
    public R GetSomething()
    {
        // Some code.
        return default(R);
    }
}
```

Classes that implement variant interfaces are invariant. For example, consider the following code.

```
// The interface is covariant.
ICovariant<Button> ibutton = new SampleImplementation<Button>();
ICovariant<Object> iobj = ibutton;

// The class is invariant.
SampleImplementation<Button> button = new SampleImplementation<Button>();
// The following statement generates a compiler error
// because classes are invariant.
// SampleImplementation<Object> obj = button;
```

Extending Variant Generic Interfaces

When you extend a variant generic interface, you have to use the `in` and `out` keywords to explicitly specify whether the derived interface supports variance. The compiler does not infer the variance from the interface that is being extended. For example, consider the following interfaces.

```
interface ICovariant<out T> { }
interface IInvariant<T> : ICovariant<T> { }
interface IExtCovariant<out T> : ICovariant<T> { }
```

In the `IInvariant<T>` interface, the generic type parameter `T` is invariant, whereas in `IExtCovariant<out T>` the type parameter is covariant, although both interfaces extend the same interface. The same rule is applied to contravariant generic type parameters.

You can create an interface that extends both the interface where the generic type parameter `T` is covariant and the interface where it is contravariant if in the extending interface the generic type parameter `T` is invariant. This is illustrated in the following code example.

```
interface ICovariant<out T> { }
interface IContravariant<in T> { }
interface IInvariant<T> : ICovariant<T>, IContravariant<T> { }
```

However, if a generic type parameter `T` is declared covariant in one interface, you cannot declare it contravariant in the extending interface, or vice versa. This is illustrated in the following code example.

```
interface ICovariant<out T> { }
// The following statement generates a compiler error.
// interface ICoContraVariant<in T> : ICovariant<T> { }
```

Avoiding Ambiguity

When you implement variant generic interfaces, variance can sometimes lead to ambiguity. This should be avoided.

For example, if you explicitly implement the same variant generic interface with different generic type parameters in one class, it can create ambiguity. The compiler does not produce an error in this case, but it is not specified which interface implementation will be chosen at runtime. This could lead to subtle bugs in your code. Consider the following code example.

```
// Simple class hierarchy.
class Animal { }
class Cat : Animal { }
class Dog : Animal { }

// This class introduces ambiguity
// because IEnumerable<out T> is covariant.
class Pets : IEnumerable<Cat>, IEnumerable<Dog>
{
    IEnumerator<Cat> IEnumerable<Cat>.GetEnumerator()
    {
        Console.WriteLine("Cat");
        // Some code.
        return null;
    }

    IEnumerator IEnumerable.GetEnumerator()
    {
        // Some code.
        return null;
    }

    IEnumerator<Dog> IEnumerable<Dog>.GetEnumerator()
    {
        Console.WriteLine("Dog");
        // Some code.
        return null;
    }
}
class Program
{
    public static void Test()
    {
        IEnumerable<Animal> pets = new Pets();
        pets.GetEnumerator();
    }
}
```

In this example, it is unspecified how the `pets.GetEnumerator` method chooses between `Cat` and `Dog`. This could cause problems in your code.

See also

- Variance in Generic Interfaces (C#)
- Using Variance for Func and Action Generic Delegates (C#)

Using Variance in Interfaces for Generic Collections (C#)

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A covariant interface allows its methods to return more derived types than those specified in the interface. A contravariant interface allows its methods to accept parameters of less derived types than those specified in the interface.

In .NET Framework 4, several existing interfaces became covariant and contravariant. These include IEnumerable<T> and IComparable<T>. This enables you to reuse methods that operate with generic collections of base types for collections of derived types.

For a list of variant interfaces in the .NET Framework, see Variance in Generic Interfaces (C#).

Converting Generic Collections

The following example illustrates the benefits of covariance support in the IEnumerable<T> interface. The `PrintFullName` method accepts a collection of the `IEnumerable<Person>` type as a parameter. However, you can reuse it for a collection of the `IEnumerable<Employee>` type because `Employee` inherits `Person`.

```
// Simple hierarchy of classes.
public class Person
{
    public string FirstName { get; set; }
    public string LastName { get; set; }
}

public class Employee : Person { }

class Program
{
    // The method has a parameter of the IEnumerable<Person> type.
    public static void PrintFullName(IEnumerable<Person> persons)
    {
        foreach (Person person in persons)
        {
            Console.WriteLine("Name: {0} {1}",
            person.FirstName, person.LastName);
        }
    }

    public static void Test()
    {
        IEnumerable<Employee> employees = new List<Employee>();

        // You can pass IEnumerable<Employee>,
        // although the method expects IEnumerable<Person>.

        PrintFullName(employees);

    }
}
```

Comparing Generic Collections

The following example illustrates the benefits of contravariance support in the IComparer<T> interface. The `PersonComparer` class implements the `IComparer<Person>` interface. However, you can reuse this class to compare a sequence of objects of the `Employee` type because `Employee` inherits `Person`.

```
// Simple hierarchy of classes.
public class Person
{
    public string FirstName { get; set; }
    public string LastName { get; set; }
}

public class Employee : Person { }

// The custom comparer for the Person type
// with standard implementations of Equals()
// and GetHashCode() methods.
class PersonComparer : IEqualityComparer<Person>
{
    public bool Equals(Person x, Person y)
    {
        if (Object.ReferenceEquals(x, y)) return true;
        if (Object.ReferenceEquals(x, null) ||
            Object.ReferenceEquals(y, null))
            return false;
        return x.FirstName == y.FirstName && x.LastName == y.LastName;
    }
    public int GetHashCode(Person person)
    {
        if (Object.ReferenceEquals(person, null)) return 0;
        int hashFirstName = person.FirstName == null
            ? 0 : person.FirstName.GetHashCode();
        int hashLastName = person.LastName.GetHashCode();
        return hashFirstName ^ hashLastName;
    }
}

class Program
{

    public static void Test()
    {
        List<Employee> employees = new List<Employee> {
               new Employee() {FirstName = "Michael", LastName = "Alexander"},
               new Employee() {FirstName = "Jeff", LastName = "Price"}
            };

        // You can pass PersonComparer,
        // which implements IEqualityComparer<Person>,
        // although the method expects IEqualityComparer<Employee>.

        IEnumerable<Employee> noduplicates =
            employees.Distinct<Employee>(new PersonComparer());

        foreach (var employee in noduplicates)
            Console.WriteLine(employee.FirstName + " " + employee.LastName);
    }
}
```

See also

- Variance in Generic Interfaces (C#)

Variance in Delegates (C#)

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.NET Framework 3.5 introduced variance support for matching method signatures with delegate types in all delegates in C#. This means that you can assign to delegates not only methods that have matching signatures, but also methods that return more derived types (covariance) or that accept parameters that have less derived types (contravariance) than that specified by the delegate type. This includes both generic and non-generic delegates.

For example, consider the following code, which has two classes and two delegates: generic and non-generic.

```
public class First { }
public class Second : First { }
public delegate First SampleDelegate(Second a);
public delegate R SampleGenericDelegate<A, R>(A a);
```

When you create delegates of the `SampleDelegate` or `SampleGenericDelegate<A, R>` types, you can assign any one of the following methods to those delegates.

```
// Matching signature.
public static First ASecondRFirst(Second first)
{ return new First(); }

// The return type is more derived.
public static Second ASecondRSecond(Second second)
{ return new Second(); }

// The argument type is less derived.
public static First AFirstRFirst(First first)
{ return new First(); }

// The return type is more derived
// and the argument type is less derived.
public static Second AFirstRSecond(First first)
{ return new Second(); }
```

The following code example illustrates the implicit conversion between the method signature and the delegate type.

```
// Assigning a method with a matching signature
// to a non-generic delegate. No conversion is necessary.
SampleDelegate dNonGeneric = ASecondRFirst;
// Assigning a method with a more derived return type
// and less derived argument type to a non-generic delegate.
// The implicit conversion is used.
SampleDelegate dNonGenericConversion = AFirstRSecond;

// Assigning a method with a matching signature to a generic delegate.
// No conversion is necessary.
SampleGenericDelegate<Second, First> dGeneric = ASecondRFirst;
// Assigning a method with a more derived return type
// and less derived argument type to a generic delegate.
// The implicit conversion is used.
SampleGenericDelegate<Second, First> dGenericConversion = AFirstRSecond;
```

For more examples, see Using Variance in Delegates (C#) and Using Variance for Func and Action Generic Delegates (C#).

Variance in Generic Type Parameters

In .NET Framework 4 or later you can enable implicit conversion between delegates, so that generic delegates that have different types specified by generic type parameters can be assigned to each other, if the types are inherited from each other as required by variance.

To enable implicit conversion, you must explicitly declare generic parameters in a delegate as covariant or contravariant by using the `in` or `out` keyword.

The following code example shows how you can create a delegate that has a covariant generic type parameter.

```
// Type T is declared covariant by using the out keyword.
public delegate T SampleGenericDelegate <out T>();

public static void Test()
{
    SampleGenericDelegate <String> dString = () => " ";

    // You can assign delegates to each other,
    // because the type T is declared covariant.
    SampleGenericDelegate <Object> dObject = dString;
}
```

If you use only variance support to match method signatures with delegate types and do not use the `in` and `out` keywords, you may find that sometimes you can instantiate delegates with identical lambda expressions or methods, but you cannot assign one delegate to another.

In the following code example, `SampleGenericDelegate<String>` cannot be explicitly converted to `SampleGenericDelegate<Object>`, although `String` inherits `Object`. You can fix this problem by marking the generic parameter `T` with the `out` keyword.

```
public delegate T SampleGenericDelegate<T>();

public static void Test()
{
    SampleGenericDelegate<String> dString = () => " ";

    // You can assign the dObject delegate
    // to the same lambda expression as dString delegate
    // because of the variance support for
    // matching method signatures with delegate types.
    SampleGenericDelegate<Object> dObject = () => " ";

    // The following statement generates a compiler error
    // because the generic type T is not marked as covariant.
    // SampleGenericDelegate <Object> dObject = dString;

}
```

Generic Delegates That Have Variant Type Parameters in the .NET Framework

.NET Framework 4 introduced variance support for generic type parameters in several existing generic delegates:

- `Action` delegates from the System namespace, for example, Action<T> and Action<T1,T2>
- `Func` delegates from the System namespace, for example, Func<TResult> and Func<T,TResult>
- The Predicate<T> delegate

- The Comparison<T> delegate
- The Converter<TInput,TOutput> delegate

For more information and examples, see Using Variance for Func and Action Generic Delegates (C#).

Declaring Variant Type Parameters in Generic Delegates

If a generic delegate has covariant or contravariant generic type parameters, it can be referred to as a *variant generic delegate*.

You can declare a generic type parameter covariant in a generic delegate by using the `out` keyword. The covariant type can be used only as a method return type and not as a type of method arguments. The following code example shows how to declare a covariant generic delegate.

```
public delegate R DCovariant<out R>();
```

You can declare a generic type parameter contravariant in a generic delegate by using the `in` keyword. The contravariant type can be used only as a type of method arguments and not as a method return type. The following code example shows how to declare a contravariant generic delegate.

```
public delegate void DContravariant<in A>(A a);
```

IMPORTANT

`ref`, `in`, and `out` parameters in C# can't be marked as variant.

It is also possible to support both variance and covariance in the same delegate, but for different type parameters. This is shown in the following example.

```
public delegate R DVariant<in A, out R>(A a);
```

Instantiating and Invoking Variant Generic Delegates

You can instantiate and invoke variant delegates just as you instantiate and invoke invariant delegates. In the following example, the delegate is instantiated by a lambda expression.

```
DVariant<String, String> dvariant = (String str) => str + " ";
dvariant("test");
```

Combining Variant Generic Delegates

You should not combine variant delegates. The Combine method does not support variant delegate conversion and expects delegates to be of exactly the same type. This can lead to a run-time exception when you combine delegates either by using the Combine method or by using the `+` operator, as shown in the following code example.

```
Action<object> actObj = x => Console.WriteLine("object: {0}", x);
Action<string> actStr = x => Console.WriteLine("string: {0}", x);
// All of the following statements throw exceptions at run time.
// Action<string> actCombine = actStr + actObj;
// actStr += actObj;
// Delegate.Combine(actStr, actObj);
```

Variance in Generic Type Parameters for Value and Reference Types

Variance for generic type parameters is supported for reference types only. For example, `DVariant<int>` can't be implicitly converted to `DVariant<Object>` or `DVariant<long>`, because integer is a value type.

The following example demonstrates that variance in generic type parameters is not supported for value types.

```
// The type T is covariant.
public delegate T DVariant<out T>();

// The type T is invariant.
public delegate T DInvariant<T>();

public static void Test()
{
    int i = 0;
    DInvariant<int> dInt = () => i;
    DVariant<int> dVariantInt = () => i;

    // All of the following statements generate a compiler error
    // because type variance in generic parameters is not supported
    // for value types, even if generic type parameters are declared variant.
    // DInvariant<Object> dObject = dInt;
    // DInvariant<long> dLong = dInt;
    // DVariant<Object> dVariantObject = dVariantInt;
    // DVariant<long> dVariantLong = dVariantInt;
}
```

See also

- Generics
- Using Variance for Func and Action Generic Delegates (C#)
- How to: Combine Delegates (Multicast Delegates)

Using Variance in Delegates (C#)

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When you assign a method to a delegate, *covariance* and *contravariance* provide flexibility for matching a delegate type with a method signature. Covariance permits a method to have return type that is more derived than that defined in the delegate. Contravariance permits a method that has parameter types that are less derived than those in the delegate type.

Example 1: Covariance

Description

This example demonstrates how delegates can be used with methods that have return types that are derived from the return type in the delegate signature. The data type returned by `DogsHandler` is of type `Dogs`, which derives from the `Mammals` type that is defined in the delegate.

Code

```
class Mammals {}
class Dogs : Mammals {}

class Program
{
    // Define the delegate.
    public delegate Mammals HandlerMethod();

    public static Mammals MammalsHandler()
    {
        return null;
    }

    public static Dogs DogsHandler()
    {
        return null;
    }

    static void Test()
    {
        HandlerMethod handlerMammals = MammalsHandler;

        // Covariance enables this assignment.
        HandlerMethod handlerDogs = DogsHandler;
    }
}
```

Example 2: Contravariance

Description

This example demonstrates how delegates can be used with methods that have parameters of a type that are base types of the delegate signature parameter type. With contravariance, you can use one event handler instead of separate handlers. For example, you can create an event handler that accepts an `EventArgs` input parameter and use it with a `Button.MouseClick` event that sends a `MouseEventArgs` type as a parameter, and also with a `TextBox.KeyDown` event that sends a `KeyEventArgs` parameter.

Code

```
// Event handler that accepts a parameter of the EventArgs type.
private void MultiHandler(object sender, System.EventArgs e)
{
    label1.Text = System.DateTime.Now.ToString();
}

public Form1()
{
    InitializeComponent();

    // You can use a method that has an EventArgs parameter,
    // although the event expects the KeyEventArgs parameter.
    this.button1.KeyDown += this.MultiHandler;

    // You can use the same method
    // for an event that expects the MouseEventArgs parameter.
    this.button1.MouseClick += this.MultiHandler;

}
```

See also

- Variance in Delegates (C#)
- Using Variance for Func and Action Generic Delegates (C#)

Using Variance for Func and Action Generic Delegates (C#)

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These examples demonstrate how to use covariance and contravariance in the `Func` and `Action` generic delegates to enable reuse of methods and provide more flexibility in your code.

For more information about covariance and contravariance, see Variance in Delegates (C#).

Using Delegates with Covariant Type Parameters

The following example illustrates the benefits of covariance support in the generic `Func` delegates. The `FindByTitle` method takes a parameter of the `String` type and returns an object of the `Employee` type. However, you can assign this method to the `Func<String, Person>` delegate because `Employee` inherits `Person`.

```
// Simple hierarchy of classes.
public class Person { }
public class Employee : Person { }
class Program
{
    static Employee FindByTitle(String title)
    {
        // This is a stub for a method that returns
        // an employee that has the specified title.
        return new Employee();
    }

    static void Test()
    {
        // Create an instance of the delegate without using variance.
        Func<String, Employee> findEmployee = FindByTitle;

        // The delegate expects a method to return Person,
        // but you can assign it a method that returns Employee.
        Func<String, Person> findPerson = FindByTitle;

        // You can also assign a delegate
        // that returns a more derived type
        // to a delegate that returns a less derived type.
        findPerson = findEmployee;

    }
}
```

Using Delegates with Contravariant Type Parameters

The following example illustrates the benefits of contravariance support in the generic `Action` delegates. The `AddToContacts` method takes a parameter of the `Person` type. However, you can assign this method to the `Action<Employee>` delegate because `Employee` inherits `Person`.

```
public class Person { }
public class Employee : Person { }
class Program
{
    static void AddToContacts(Person person)
    {
        // This method adds a Person object
        // to a contact list.
    }

    static void Test()
    {
        // Create an instance of the delegate without using variance.
        Action<Person> addPersonToContacts = AddToContacts;

        // The Action delegate expects
        // a method that has an Employee parameter,
        // but you can assign it a method that has a Person parameter
        // because Employee derives from Person.
        Action<Employee> addEmployeeToContacts = AddToContacts;

        // You can also assign a delegate
        // that accepts a less derived parameter to a delegate
        // that accepts a more derived parameter.
        addEmployeeToContacts = addPersonToContacts;
    }
}
```

See also

- Covariance and Contravariance (C#)
- Generics

Contents

Expression Trees (C#)

1/23/2019 • 4 minutes to read • Edit Online

Expression trees represent code in a tree-like data structure, where each node is an expression, for example, a method call or a binary operation such as `x < y`.

You can compile and run code represented by expression trees. This enables dynamic modification of executable code, the execution of LINQ queries in various databases, and the creation of dynamic queries. For more information about expression trees in LINQ, see How to: Use Expression Trees to Build Dynamic Queries (C#).

Expression trees are also used in the dynamic language runtime (DLR) to provide interoperability between dynamic languages and the .NET Framework and to enable compiler writers to emit expression trees instead of Microsoft intermediate language (MSIL). For more information about the DLR, see Dynamic Language Runtime Overview.

You can have the C# or Visual Basic compiler create an expression tree for you based on an anonymous lambda expression, or you can create expression trees manually by using the System.Linq.Expressions namespace.

Creating Expression Trees from Lambda Expressions

When a lambda expression is assigned to a variable of type Expression<TDelegate>, the compiler emits code to build an expression tree that represents the lambda expression.

The C# compiler can generate expression trees only from expression lambdas (or single-line lambdas). It cannot parse statement lambdas (or multi-line lambdas). For more information about lambda expressions in C#, see Lambda Expressions.

The following code examples demonstrate how to have the C# compiler create an expression tree that represents the lambda expression `num => num < 5`.

```
Expression<Func<int, bool>> lambda = num => num < 5;
```

Creating Expression Trees by Using the API

To create expression trees by using the API, use the Expression class. This class contains static factory methods that create expression tree nodes of specific types, for example, ParameterExpression, which represents a variable or parameter, or MethodCallExpression, which represents a method call. ParameterExpression, MethodCallExpression, and the other expression-specific types are also defined in the System.Linq.Expressions namespace. These types derive from the abstract type Expression.

The following code example demonstrates how to create an expression tree that represents the lambda expression `num => num < 5` by using the API.

```
// Add the following using directive to your code file:
// using System.Linq.Expressions;

// Manually build the expression tree for
// the lambda expression num => num < 5.
ParameterExpression numParam = Expression.Parameter(typeof(int), "num");
ConstantExpression five = Expression.Constant(5, typeof(int));
BinaryExpression numLessThanFive = Expression.LessThan(numParam, five);
Expression<Func<int, bool>> lambda1 =
    Expression.Lambda<Func<int, bool>>(
        numLessThanFive,
        new ParameterExpression[] { numParam });
```

In .NET Framework 4 or later, the expression trees API also supports assignments and control flow expressions such as loops, conditional blocks, and `try-catch` blocks. By using the API, you can create expression trees that are more complex than those that can be created from lambda expressions by the C# compiler. The following example demonstrates how to create an expression tree that calculates the factorial of a number.

```
// Creating a parameter expression.
ParameterExpression value = Expression.Parameter(typeof(int), "value");

// Creating an expression to hold a local variable.
ParameterExpression result = Expression.Parameter(typeof(int), "result");

// Creating a label to jump to from a loop.
LabelTarget label = Expression.Label(typeof(int));

// Creating a method body.
BlockExpression block = Expression.Block(
    // Adding a local variable.
    new[] { result },
    // Assigning a constant to a local variable: result = 1
    Expression.Assign(result, Expression.Constant(1)),
    // Adding a loop.
        Expression.Loop(
    // Adding a conditional block into the loop.
           Expression.IfThenElse(
    // Condition: value > 1
               Expression.GreaterThan(value, Expression.Constant(1)),
    // If true: result *= value --
               Expression.MultiplyAssign(result,
                   Expression.PostDecrementAssign(value)),
    // If false, exit the loop and go to the label.
               Expression.Break(label, result)
           ),
    // Label to jump to.
       label
    )
);

// Compile and execute an expression tree.
int factorial = Expression.Lambda<Func<int, int>>(block, value).Compile()(5);

Console.WriteLine(factorial);
// Prints 120.
```

For more information, see Generating Dynamic Methods with Expression Trees in Visual Studio 2010, which also applies to later versions of Visual Studio.

Parsing Expression Trees

The following code example demonstrates how the expression tree that represents the lambda expression `num => num < 5` can be decomposed into its parts.

```
// Add the following using directive to your code file:
// using System.Linq.Expressions;

// Create an expression tree.
Expression<Func<int, bool>> exprTree = num => num < 5;

// Decompose the expression tree.
ParameterExpression param = (ParameterExpression)exprTree.Parameters[0];
BinaryExpression operation = (BinaryExpression)exprTree.Body;
ParameterExpression left = (ParameterExpression)operation.Left;
ConstantExpression right = (ConstantExpression)operation.Right;

Console.WriteLine("Decomposed expression: {0} => {1} {2} {3}",
                  param.Name, left.Name, operation.NodeType, right.Value);

// This code produces the following output:

// Decomposed expression: num => num LessThan 5
```

Immutability of Expression Trees

Expression trees should be immutable. This means that if you want to modify an expression tree, you must construct a new expression tree by copying the existing one and replacing nodes in it. You can use an expression tree visitor to traverse the existing expression tree. For more information, see How to: Modify Expression Trees (C#).

Compiling Expression Trees

The Expression<TDelegate> type provides the Compile method that compiles the code represented by an expression tree into an executable delegate.

The following code example demonstrates how to compile an expression tree and run the resulting code.

```
// Creating an expression tree.
Expression<Func<int, bool>> expr = num => num < 5;

// Compiling the expression tree into a delegate.
Func<int, bool> result = expr.Compile();

// Invoking the delegate and writing the result to the console.
Console.WriteLine(result(4));

// Prints True.

// You can also use simplified syntax
// to compile and run an expression tree.
// The following line can replace two previous statements.
Console.WriteLine(expr.Compile()(4));

// Also prints True.
```

For more information, see How to: Execute Expression Trees (C#).

See also

- System.Linq.Expressions
- How to: Execute Expression Trees (C#)

- How to: Modify Expression Trees (C#)
- Lambda Expressions
- Dynamic Language Runtime Overview
- Programming Concepts (C#)

How to: Execute Expression Trees (C#)

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This topic shows you how to execute an expression tree. Executing an expression tree may return a value, or it may just perform an action such as calling a method.

Only expression trees that represent lambda expressions can be executed. Expression trees that represent lambda expressions are of type LambdaExpression or Expression<TDelegate>. To execute these expression trees, call the Compile method to create an executable delegate, and then invoke the delegate.

NOTE

If the type of the delegate is not known, that is, the lambda expression is of type LambdaExpression and not Expression<TDelegate>, you must call the DynamicInvoke method on the delegate instead of invoking it directly.

If an expression tree does not represent a lambda expression, you can create a new lambda expression that has the original expression tree as its body, by calling the Lambda<TDelegate>(Expression, IEnumerable<ParameterExpression>) method. Then, you can execute the lambda expression as described earlier in this section.

Example

The following code example demonstrates how to execute an expression tree that represents raising a number to a power by creating a lambda expression and executing it. The result, which represents the number raised to the power, is displayed.

```
// The expression tree to execute.
BinaryExpression be = Expression.Power(Expression.Constant(2D), Expression.Constant(3D));

// Create a lambda expression.
Expression<Func<double>> le = Expression.Lambda<Func<double>>(be);

// Compile the lambda expression.
Func<double> compiledExpression = le.Compile();

// Execute the lambda expression.
double result = compiledExpression();

// Display the result.
Console.WriteLine(result);

// This code produces the following output:
// 8
```

Compiling the Code

- Add a project reference to System.Core.dll if it is not already referenced.
- Include the System.Linq.Expressions namespace.

See also

- Expression Trees (C#)

- How to: Modify Expression Trees (C#)

How to: Modify Expression Trees (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows you how to modify an expression tree. Expression trees are immutable, which means that they cannot be modified directly. To change an expression tree, you must create a copy of an existing expression tree and when you create the copy, make the required changes. You can use the ExpressionVisitor class to traverse an existing expression tree and to copy each node that it visits.

To modify an expression tree

1. Create a new **Console Application** project.
2. Add a `using` directive to the file for the `System.Linq.Expressions` namespace.
3. Add the `AndAlsoModifier` class to your project.

```
public class AndAlsoModifier : ExpressionVisitor
{
    public Expression Modify(Expression expression)
    {
        return Visit(expression);
    }

    protected override Expression VisitBinary(BinaryExpression b)
    {
        if (b.NodeType == ExpressionType.AndAlso)
        {
            Expression left = this.Visit(b.Left);
            Expression right = this.Visit(b.Right);

            // Make this binary expression an OrElse operation instead of an AndAlso operation.
            return Expression.MakeBinary(ExpressionType.OrElse, left, right, b.IsLiftedToNull,
b.Method);
        }

        return base.VisitBinary(b);
    }
}
```

   This class inherits the ExpressionVisitor class and is specialized to modify expressions that represent conditional `AND` operations. It changes these operations from a conditional `AND` to a conditional `OR`. To do this, the class overrides the VisitBinary method of the base type, because conditional `AND` expressions are represented as binary expressions. In the `VisitBinary` method, if the expression that is passed to it represents a conditional `AND` operation, the code constructs a new expression that contains the conditional `OR` operator instead of the conditional `AND` operator. If the expression that is passed to `VisitBinary` does not represent a conditional `AND` operation, the method defers to the base class implementation. The base class methods construct nodes that are like the expression trees that are passed in, but the nodes have their sub trees replaced with the expression trees that are produced recursively by the visitor.

4. Add a `using` directive to the file for the `System.Linq.Expressions` namespace.
5. Add code to the `Main` method in the Program.cs file to create an expression tree and pass it to the method that will modify it.

```
Expression<Func<string, bool>> expr = name => name.Length > 10 && name.StartsWith("G");
Console.WriteLine(expr);

AndAlsoModifier treeModifier = new AndAlsoModifier();
Expression modifiedExpr = treeModifier.Modify((Expression) expr);

Console.WriteLine(modifiedExpr);

/*  This code produces the following output:

    name => ((name.Length > 10) && name.StartsWith("G"))
    name => ((name.Length > 10) || name.StartsWith("G"))
*/
```

The code creates an expression that contains a conditional `AND` operation. It then creates an instance of the `AndAlsoModifier` class and passes the expression to the `Modify` method of this class. Both the original and the modified expression trees are outputted to show the change.

6. Compile and run the application.

See also

- How to: Execute Expression Trees (C#)
- Expression Trees (C#)

How to: Use Expression Trees to Build Dynamic Queries (C#)

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In LINQ, expression trees are used to represent structured queries that target sources of data that implement IQueryable<T>. For example, the LINQ provider implements the IQueryable<T> interface for querying relational data stores. The C# compiler compiles queries that target such data sources into code that builds an expression tree at runtime. The query provider can then traverse the expression tree data structure and translate it into a query language appropriate for the data source.

Expression trees are also used in LINQ to represent lambda expressions that are assigned to variables of type Expression<TDelegate>.

This topic describes how to use expression trees to create dynamic LINQ queries. Dynamic queries are useful when the specifics of a query are not known at compile time. For example, an application might provide a user interface that enables the end user to specify one or more predicates to filter the data. In order to use LINQ for querying, this kind of application must use expression trees to create the LINQ query at runtime.

Example

The following example shows you how to use expression trees to construct a query against an `IQueryable` data source and then execute it. The code builds an expression tree to represent the following query:

```
companies.Where(company => (company.ToLower() == "coho winery" || company.Length > 16)).OrderBy(company =>
company)
```

The factory methods in the System.Linq.Expressions namespace are used to create expression trees that represent the expressions that make up the overall query. The expressions that represent calls to the standard query operator methods refer to the Queryable implementations of these methods. The final expression tree is passed to the CreateQuery<TElement>(Expression) implementation of the provider of the `IQueryable` data source to create an executable query of type `IQueryable`. The results are obtained by enumerating that query variable.

```
// Add a using directive for System.Linq.Expressions.

string[] companies = { "Consolidated Messenger", "Alpine Ski House", "Southridge Video", "City Power & Light",
                   "Coho Winery", "Wide World Importers", "Graphic Design Institute", "Adventure Works",
                   "Humongous Insurance", "Woodgrove Bank", "Margie's Travel", "Northwind Traders",
                   "Blue Yonder Airlines", "Trey Research", "The Phone Company",
                   "Wingtip Toys", "Lucerne Publishing", "Fourth Coffee" };

// The IQueryable data to query.
IQueryable<String> queryableData = companies.AsQueryable<string>();

// Compose the expression tree that represents the parameter to the predicate.
ParameterExpression pe = Expression.Parameter(typeof(string), "company");

// ***** Where(company => (company.ToLower() == "coho winery" || company.Length > 16)) *****
// Create an expression tree that represents the expression 'company.ToLower() == "coho winery"'.
Expression left = Expression.Call(pe, typeof(string).GetMethod("ToLower", System.Type.EmptyTypes));
Expression right = Expression.Constant("coho winery");
Expression e1 = Expression.Equal(left, right);

// Create an expression tree that represents the expression 'company.Length > 16'.
left = Expression.Property(pe, typeof(string).GetProperty("Length"));
right = Expression.Constant(16, typeof(int));
Expression e2 = Expression.GreaterThan(left, right);
Expression e2 = Expression.GreaterThan(left, right);

// Combine the expression trees to create an expression tree that represents the
// expression '(company.ToLower() == "coho winery" || company.Length > 16)'.
Expression predicateBody = Expression.OrElse(e1, e2);

// Create an expression tree that represents the expression
// 'queryableData.Where(company => (company.ToLower() == "coho winery" || company.Length > 16))'
MethodCallExpression whereCallExpression = Expression.Call(
    typeof(Queryable),
    "Where",
    new Type[] { queryableData.ElementType },
    queryableData.Expression,
    Expression.Lambda<Func<string, bool>>(predicateBody, new ParameterExpression[] { pe }));
// ***** End Where *****

// ***** OrderBy(company => company) *****
// Create an expression tree that represents the expression
// 'whereCallExpression.OrderBy(company => company)'
MethodCallExpression orderByCallExpression = Expression.Call(
    typeof(Queryable),
    "OrderBy",
    new Type[] { queryableData.ElementType, queryableData.ElementType },
    whereCallExpression,
    Expression.Lambda<Func<string, string>>(pe, new ParameterExpression[] { pe }));
// ***** End OrderBy *****

// Create an executable query from the expression tree.
IQueryable<string> results = queryableData.Provider.CreateQuery<string>(orderByCallExpression);

// Enumerate the results.
foreach (string company in results)
    Console.WriteLine(company);

/*  This code produces the following output:

    Blue Yonder Airlines
    City Power & Light
    Coho Winery
    Consolidated Messenger
    Graphic Design Institute
    Humongous Insurance
    Lucerne Publishing
    Northwind Traders
    The Phone Company
    Wide World Importers
*/
```

This code uses a fixed number of expressions in the predicate that is passed to the `Queryable.Where` method. However, you can write an application that combines a variable number of predicate expressions that depends on the user input. You can also vary the standard query operators that are called in the query, depending on the input from the user.

Compiling the Code

- Create a new **Console Application** project.
- Add a reference to System.Core.dll if it is not already referenced.
- Include the System.Linq.Expressions namespace.
- Copy the code from the example and paste it into the `Main` method.

See also

- Expression Trees (C#)
- How to: Execute Expression Trees (C#)
- How to: Dynamically Specify Predicate Filters at Runtime

Debugging Expression Trees in Visual Studio (C#)

1/23/2019 • 2 minutes to read • Edit Online

You can analyze the structure and content of expression trees when you debug your applications. To get a quick overview of the expression tree structure, you can use the `DebugView` property, which is available only in debug mode. For more information about debugging, see Debugging in Visual Studio.

To better represent the content of expression trees, the `DebugView` property uses Visual Studio visualizers. For more information, see Create Custom Visualizers.

To open a visualizer for an expression tree

1. Click the magnifying glass icon that appears next to the `DebugView` property of an expression tree in **DataTips**, a **Watch** window, the **Autos** window, or the **Locals** window.

   A list of visualizers is displayed.

2. Click the visualizer you want to use.

Each expression type is displayed in the visualizer as described in the following sections.

ParameterExpressions

ParameterExpression variable names are displayed with a "$" symbol at the beginning.

If a parameter does not have a name, it is assigned an automatically generated name, such as `$var1` or `$var2`.

Examples

EXPRESSION	`DEBUGVIEW` PROPERTY
`ParameterExpression numParam = Expression.Parameter(typeof(int), "num");`	`$num`
`ParameterExpression numParam = Expression.Parameter(typeof(int));`	`$var1`

ConstantExpressions

For ConstantExpression objects that represent integer values, strings, and `null`, the value of the constant is displayed.

For numeric types that have standard suffixes as C# literals, the suffix is added to the value. The following table shows the suffixes associated with various numeric types.

TYPE	SUFFIX
UInt32	U
Int64	L
UInt64	UL

TYPE	SUFFIX
Double	D
Single	F
Decimal	M

Examples

EXPRESSION	`DEBUGVIEW` PROPERTY
`int num = 10; ConstantExpression expr = Expression.Constant(num);`	10
`double num = 10; ConstantExpression expr = Expression.Constant(num);`	10D

BlockExpression

If the type of a BlockExpression object differs from the type of the last expression in the block, the type is displayed in the `DebugInfo` property in angle brackets (< and >). Otherwise, the type of the BlockExpression object is not displayed.

Examples

EXPRESSION	`DEBUGVIEW` PROPERTY
`BlockExpression block = Expression.Block(Expression.Constant("test"));`	`.Block() {` `"test"` `}`
`BlockExpression block = Expression.Block(typeof(Object), Expression.Constant("test"));`	`.Block<System.Object>() {` `"test"` `}`

LambdaExpression

LambdaExpression objects are displayed together with their delegate types.

If a lambda expression does not have a name, it is assigned an automatically generated name, such as `#Lambda1` or `#Lambda2`.

Examples

EXPRESSION	`DEBUGVIEW` PROPERTY

EXPRESSION	`DEBUGVIEW` PROPERTY

`LambdaExpression lambda = Expression.Lambda<Func<int>>(Expression.Constant(1));`	`.Lambda #Lambda1<System.Func'1[System.Int32]>() {`
	
	`1`
	
	`}`

`LambdaExpression lambda = Expression.Lambda<Func<int>>(Expression.Constant(1), "SampleLambda", null);`	`.Lambda SampleLambda<System.Func'1[System.Int32]>() {`
	
	`1`
	
	`}`

LabelExpression

If you specify a default value for the LabelExpression object, this value is displayed before the LabelTarget object.

The `.Label` token indicates the start of the label. The `.LabelTarget` token indicates the destination of the target to jump to.

If a label does not have a name, it is assigned an automatically generated name, such as `#Label1` or `#Label2`.

Examples

EXPRESSION	`DEBUGVIEW` PROPERTY

`LabelTarget target = Expression.Label(typeof(int), "SampleLabel"); BlockExpression block = Expression.Block( Expression.Goto(target, Expression.Constant(0)), Expression.Label(target, Expression.Constant(-1)));`	`.Block() {`
	
	`.Goto SampleLabel { 0 };`
	
	`.Label`
	
	`-1`
	
	`.LabelTarget SampleLabel:`
	
	`}`

`LabelTarget target = Expression.Label(); BlockExpression block = Expression.Block( Expression.Goto(target5), Expression.Label(target5));`	`.Block() {`
	
	`.Goto #Label1 { };`
	
	`.Label`
	
	`.LabelTarget #Label1:`
	
	`}`

Checked Operators

Checked operators are displayed with the "#" symbol in front of the operator. For example, the checked addition operator is displayed as `#+`.

Examples

EXPRESSION	`DEBUGVIEW` PROPERTY
`Expression expr = Expression.AddChecked( Expression.Constant(1), Expression.Constant(2));`	`1 #+ 2`
`Expression expr = Expression.ConvertChecked( Expression.Constant(10.0), typeof(int));`	`#(System.Int32)10D`

See also

- Expression Trees (C#)
- Debugging in Visual Studio
- Create Custom Visualizers

Contents

Language Integrated Query (LINQ)

10/13/2018 • 3 minutes to read • Edit Online

Language-Integrated Query (LINQ) is the name for a set of technologies based on the integration of query capabilities directly into the C# language. Traditionally, queries against data are expressed as simple strings without type checking at compile time or IntelliSense support. Furthermore, you have to learn a different query language for each type of data source: SQL databases, XML documents, various Web services, and so on. With LINQ, a query is a first-class language construct, just like classes, methods, events.

For a developer who writes queries, the most visible "language-integrated" part of LINQ is the query expression. Query expressions are written in a declarative *query syntax*. By using query syntax, you can perform filtering, ordering, and grouping operations on data sources with a minimum of code. You use the same basic query expression patterns to query and transform data in SQL databases, ADO .NET Datasets, XML documents and streams, and .NET collections.

The following example shows the complete query operation. The complete operation includes creating a data source, defining the query expression, and executing the query in a `foreach` statement.

```
class LINQQueryExpressions
{
    static void Main()
    {

        // Specify the data source.
        int[] scores = new int[] { 97, 92, 81, 60 };

        // Define the query expression.
        IEnumerable<int> scoreQuery =
            from score in scores
            where score > 80
            select score;

        // Execute the query.
        foreach (int i in scoreQuery)
        {
            Console.Write(i + " ");
        }
    }
}
// Output: 97 92 81
```

Query expression overview

- Query expressions can be used to query and to transform data from any LINQ-enabled data source. For example, a single query can retrieve data from a SQL database, and produce an XML stream as output.
- Query expressions are easy to master because they use many familiar C# language constructs.
- The variables in a query expression are all strongly typed, although in many cases you do not have to provide the type explicitly because the compiler can infer it. For more information, see Type relationships in LINQ query operations.
- A query is not executed until you iterate over the query variable, for example, in a `foreach` statement. For more information, see Introduction to LINQ queries.

- At compile time, query expressions are converted to Standard Query Operator method calls according to the rules set forth in the C# specification. Any query that can be expressed by using query syntax can also be expressed by using method syntax. However, in most cases query syntax is more readable and concise. For more information, see C# language specification and Standard query operators overview.
- As a rule when you write LINQ queries, we recommend that you use query syntax whenever possible and method syntax whenever necessary. There is no semantic or performance difference between the two different forms. Query expressions are often more readable than equivalent expressions written in method syntax.
- Some query operations, such as Count or Max, have no equivalent query expression clause and must therefore be expressed as a method call. Method syntax can be combined with query syntax in various ways. For more information, see Query syntax and method syntax in LINQ.
- Query expressions can be compiled to expression trees or to delegates, depending on the type that the query is applied to. IEnumerable<T> queries are compiled to delegates. IQueryable and IQueryable<T> queries are compiled to expression trees. For more information, see Expression trees.

Next steps

To learn more details about LINQ, start by becoming familiar with some basic concepts in Query expression basics, and then read the documentation for the LINQ technology in which you are interested:

- XML documents: LINQ to XML
- ADO.NET Entity Framework: LINQ to entities
- .NET collections, files, strings and so on: LINQ to objects

To gain a deeper understanding of LINQ in general, see LINQ in C#.

To start working with LINQ in C#, see the tutorial Working with LINQ.

Introduction to LINQ (C#)

1/23/2019 • 2 minutes to read • Edit Online

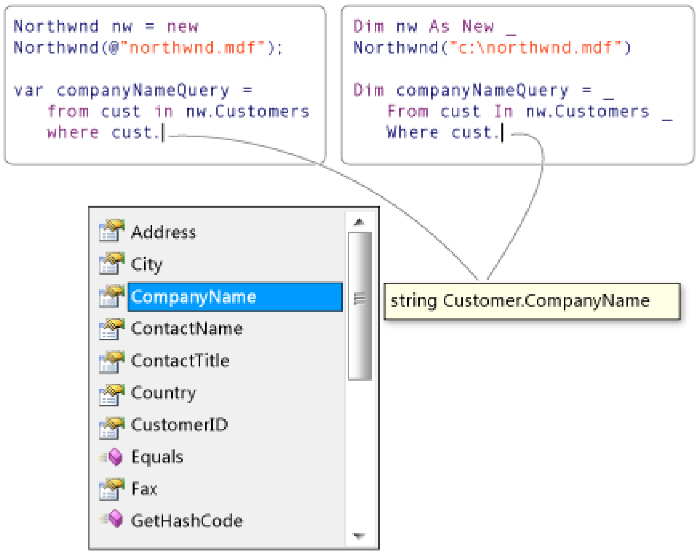
Language-Integrated Query (LINQ) is an innovation introduced in the .NET Framework version 3.5 that bridges the gap between the world of objects and the world of data.

Traditionally, queries against data are expressed as simple strings without type checking at compile time or IntelliSense support. Furthermore, you have to learn a different query language for each type of data source: SQL databases, XML documents, various Web services, and so on. LINQ makes a *query* a first-class language construct in C#. You write queries against strongly typed collections of objects by using language keywords and familiar operators.

You can write LINQ queries in C# for SQL Server databases, XML documents, ADO.NET Datasets, and any collection of objects that supports IEnumerable or the generic IEnumerable<T> interface. LINQ support is also provided by third parties for many Web services and other database implementations.

You can use LINQ queries in new projects, or alongside non-LINQ queries in existing projects. The only requirement is that the project target .NET Framework 3.5 or later.

The following illustration from Visual Studio shows a partially-completed LINQ query against a SQL Server database in both C# and Visual Basic with full type checking and IntelliSense support.



```
Northwnd nw = new
Northwnd(@"northwnd.mdf");

var companyNameQuery =
    from cust in nw.Customers
    where cust.
```

```
Dim nw As New _
Northwnd("c:\northwnd.mdf")

Dim companyNameQuery = _
    From cust In nw.Customers _
    Where cust.
```

Next Steps

To learn more details about LINQ, start by becoming familiar with some basic concepts in the Getting Started section Getting Started with LINQ in C#, and then read the documentation for the LINQ technology in which you are interested:

- SQL Server databases: LINQ to SQL
- XML documents: LINQ to XML (C#)
- ADO.NET Datasets: LINQ to DataSet
- .NET collections, files, strings and so on: LINQ to Objects (C#)

See also

- Language-Integrated Query (LINQ) (C#)

Getting Started with LINQ in C#

5/4/2018 • 2 minutes to read • Edit Online

This section contains basic background information that will help you understand the rest of the LINQ documentation and samples.

In This Section

Introduction to LINQ Queries (C#)
Describes the three parts of the basic LINQ query operation that are common across all languages and data sources.

LINQ and Generic Types (C#)
Provides a brief introduction to generic types as they are used in LINQ.

Basic LINQ Query Operations
Describes the most common types of query operations and how they are expressed in C#.

Data Transformations with LINQ (C#)
Describes the various ways that you can transform data retrieved in queries.

Type Relationships in LINQ Query Operations
Describes how types are preserved and/or transformed in the three parts of a LINQ query operation

Query Syntax and Method Syntax in LINQ
Compares method syntax and query syntax as two ways to express a LINQ query.

C# Features That Support LINQ
Describes the language constructs added in C# 3.0 that support LINQ.

Walkthrough: Writing Queries in C#
Step-by-step instructions for creating a C# LINQ project, adding a simple data source, and performing some basic query operations.

Related Sections

Language-Integrated Query (LINQ) (C#)
Provides links to topics that explain the LINQ technologies.

LINQ Query Expressions
Includes an overview of queries in LINQ and provides links to additional resources.

Visual Studio IDE and Tools Support for LINQ (C#)
Describes tools available in the Visual Studio environment for designing, coding, and debugging LINQ-enabled application.

Standard Query Operators Overview (C#)
Introduces the standard methods used in LINQ.

Getting Started with LINQ in Visual Basic
Provides links to topics about using LINQ with Visual Basic.

Introduction to LINQ Queries (C#)

1/23/2019 • 6 minutes to read • Edit Online

A *query* is an expression that retrieves data from a data source. Queries are usually expressed in a specialized query language. Different languages have been developed over time for the various types of data sources, for example SQL for relational databases and XQuery for XML. Therefore, developers have had to learn a new query language for each type of data source or data format that they must support. LINQ simplifies this situation by offering a consistent model for working with data across various kinds of data sources and formats. In a LINQ query, you are always working with objects. You use the same basic coding patterns to query and transform data in XML documents, SQL databases, ADO.NET Datasets, .NET collections, and any other format for which a LINQ provider is available.

Three Parts of a Query Operation

All LINQ query operations consist of three distinct actions:

1. Obtain the data source.
2. Create the query.
3. Execute the query.

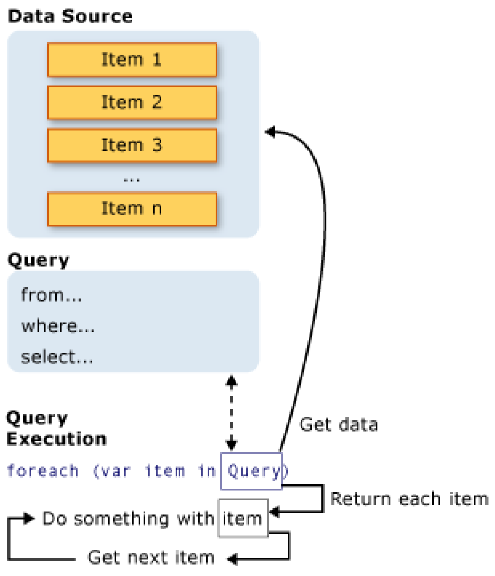
The following example shows how the three parts of a query operation are expressed in source code. The example uses an integer array as a data source for convenience; however, the same concepts apply to other data sources also. This example is referred to throughout the rest of this topic.

```
class IntroToLINQ
{
    static void Main()
    {
        // The Three Parts of a LINQ Query:
        // 1. Data source.
        int[] numbers = new int[7] { 0, 1, 2, 3, 4, 5, 6 };

        // 2. Query creation.
        // numQuery is an IEnumerable<int>
        var numQuery =
            from num in numbers
            where (num % 2) == 0
            select num;

        // 3. Query execution.
        foreach (int num in numQuery)
        {
            Console.Write("{0,1} ", num);
        }
    }
}
```

The following illustration shows the complete query operation. In LINQ the execution of the query is distinct from the query itself; in other words you have not retrieved any data just by creating a query variable.



The Data Source

In the previous example, because the data source is an array, it implicitly supports the generic IEnumerable<T> interface. This fact means it can be queried with LINQ. A query is executed in a `foreach` statement, and `foreach` requires IEnumerable or IEnumerable<T>. Types that support IEnumerable<T> or a derived interface such as the generic IQueryable<T> are called *queryable types*.

A queryable type requires no modification or special treatment to serve as a LINQ data source. If the source data is not already in memory as a queryable type, the LINQ provider must represent it as such. For example, LINQ to XML loads an XML document into a queryable XElement type:

```
// Create a data source from an XML document.
// using System.Xml.Linq;
XElement contacts = XElement.Load(@"c:\myContactList.xml");
```

With LINQ to SQL, you first create an object-relational mapping at design time either manually or by using the LINQ to SQL Tools in Visual Studio in Visual Studio. You write your queries against the objects, and at run-time LINQ to SQL handles the communication with the database. In the following example, `Customers` represents a specific table in the database, and the type of the query result, IQueryable<T>, derives from IEnumerable<T>.

```
Northwnd db = new Northwnd(@"c:\northwnd.mdf");

// Query for customers in London.
IQueryable<Customer> custQuery =
    from cust in db.Customers
    where cust.City == "London"
    select cust;
```

For more information about how to create specific types of data sources, see the documentation for the various LINQ providers. However, the basic rule is very simple: a LINQ data source is any object that supports the generic IEnumerable<T> interface, or an interface that inherits from it.

NOTE

Types such as ArrayList that support the non-generic IEnumerable interface can also be used as a LINQ data source. For more information, see How to: Query an ArrayList with LINQ (C#).

The Query

The query specifies what information to retrieve from the data source or sources. Optionally, a query also specifies how that information should be sorted, grouped, and shaped before it is returned. A query is stored in a query variable and initialized with a query expression. To make it easier to write queries, C# has introduced new query syntax.

The query in the previous example returns all the even numbers from the integer array. The query expression contains three clauses: `from`, `where` and `select`. (If you are familiar with SQL, you will have noticed that the ordering of the clauses is reversed from the order in SQL.) The `from` clause specifies the data source, the `where` clause applies the filter, and the `select` clause specifies the type of the returned elements. These and the other query clauses are discussed in detail in the LINQ Query Expressions section. For now, the important point is that in LINQ, the query variable itself takes no action and returns no data. It just stores the information that is required to produce the results when the query is executed at some later point. For more information about how queries are constructed behind the scenes, see Standard Query Operators Overview (C#).

NOTE

Queries can also be expressed by using method syntax. For more information, see Query Syntax and Method Syntax in LINQ.

Query Execution

Deferred Execution

As stated previously, the query variable itself only stores the query commands. The actual execution of the query is deferred until you iterate over the query variable in a `foreach` statement. This concept is referred to as *deferred execution* and is demonstrated in the following example:

```
//  Query execution.
foreach (int num in numQuery)
{
    Console.Write("{0,1} ", num);
}
```

The `foreach` statement is also where the query results are retrieved. For example, in the previous query, the iteration variable `num` holds each value (one at a time) in the returned sequence.

Because the query variable itself never holds the query results, you can execute it as often as you like. For example, you may have a database that is being updated continually by a separate application. In your application, you could create one query that retrieves the latest data, and you could execute it repeatedly at some interval to retrieve different results every time.

Forcing Immediate Execution

Queries that perform aggregation functions over a range of source elements must first iterate over those elements. Examples of such queries are `Count`, `Max`, `Average`, and `First`. These execute without an explicit `foreach` statement because the query itself must use `foreach` in order to return a result. Note also that these types of queries return a single value, not an `IEnumerable` collection. The following query returns a count of the even numbers in the source array:

```
var evenNumQuery =
    from num in numbers
    where (num % 2) == 0
    select num;

int evenNumCount = evenNumQuery.Count();
```

To force immediate execution of any query and cache its results, you can call the ToList or ToArray methods.

```
List<int> numQuery2 =
    (from num in numbers
     where (num % 2) == 0
     select num).ToList();

// or like this:
// numQuery3 is still an int[]

var numQuery3 =
    (from num in numbers
     where (num % 2) == 0
     select num).ToArray();
```

You can also force execution by putting the `foreach` loop immediately after the query expression. However, by calling `ToList` or `ToArray` you also cache all the data in a single collection object.

See also

- Getting Started with LINQ in C#
- Walkthrough: Writing Queries in C#
- Walkthrough: Writing Queries in C#
- LINQ Query Expressions
- foreach, in
- Query Keywords (LINQ)

LINQ and Generic Types (C#)

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LINQ queries are based on generic types, which were introduced in version 2.0 of the .NET Framework. You do not need an in-depth knowledge of generics before you can start writing queries. However, you may want to understand two basic concepts:

1. When you create an instance of a generic collection class such as List<T>, you replace the "T" with the type of objects that the list will hold. For example, a list of strings is expressed as `List<string>`, and a list of `Customer` objects is expressed as `List<Customer>`. A generic list is strongly typed and provides many benefits over collections that store their elements as Object. If you try to add a `Customer` to a `List<string>`, you will get an error at compile time. It is easy to use generic collections because you do not have to perform run-time type-casting.

2. IEnumerable<T> is the interface that enables generic collection classes to be enumerated by using the `foreach` statement. Generic collection classes support IEnumerable<T> just as non-generic collection classes such as ArrayList support IEnumerable.

For more information about generics, see Generics.

IEnumerable<T> variables in LINQ Queries

LINQ query variables are typed as IEnumerable<T> or a derived type such as IQueryable<T>. When you see a query variable that is typed as `IEnumerable<Customer>`, it just means that the query, when it is executed, will produce a sequence of zero or more `Customer` objects.

```
IEnumerable<Customer> customerQuery =
    from cust in customers
    where cust.City == "London"
    select cust;

foreach (Customer customer in customerQuery)
{
    Console.WriteLine(customer.LastName + ", " + customer.FirstName);
}
```

For more information, see Type Relationships in LINQ Query Operations.

Letting the Compiler Handle Generic Type Declarations

If you prefer, you can avoid generic syntax by using the var keyword. The `var` keyword instructs the compiler to infer the type of a query variable by looking at the data source specified in the `from` clause. The following example produces the same compiled code as the previous example:

```
var customerQuery2 =
    from cust in customers
    where cust.City == "London"
    select cust;

foreach(var customer in customerQuery2)
{
    Console.WriteLine(customer.LastName + ", " + customer.FirstName);
}
```

The `var` keyword is useful when the type of the variable is obvious or when it is not that important to explicitly specify nested generic types such as those that are produced by group queries. In general, we recommend that if you use `var`, realize that it can make your code more difficult for others to read. For more information, see Implicitly Typed Local Variables.

See also

- Getting Started with LINQ in C#
- Generics

Basic LINQ Query Operations (C#)

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This topic gives a brief introduction to LINQ query expressions and some of the typical kinds of operations that you perform in a query. More detailed information is in the following topics:

LINQ Query Expressions

Standard Query Operators Overview (C#)

Walkthrough: Writing Queries in C#

NOTE

If you already are familiar with a query language such as SQL or XQuery, you can skip most of this topic. Read about the " `from` clause" in the next section to learn about the order of clauses in LINQ query expressions.

Obtaining a Data Source

In a LINQ query, the first step is to specify the data source. In C# as in most programming languages a variable must be declared before it can be used. In a LINQ query, the `from` clause comes first in order to introduce the data source (`customers`) and the *range variable* (`cust`).

```
//queryAllCustomers is an IEnumerable<Customer>
var queryAllCustomers = from cust in customers
                        select cust;
```

The range variable is like the iteration variable in a `foreach` loop except that no actual iteration occurs in a query expression. When the query is executed, the range variable will serve as a reference to each successive element in `customers`. Because the compiler can infer the type of `cust`, you do not have to specify it explicitly. Additional range variables can be introduced by a `let` clause. For more information, see let clause.

NOTE

For non-generic data sources such as ArrayList, the range variable must be explicitly typed. For more information, see How to: Query an ArrayList with LINQ (C#) and from clause.

Filtering

Probably the most common query operation is to apply a filter in the form of a Boolean expression. The filter causes the query to return only those elements for which the expression is true. The result is produced by using the `where` clause. The filter in effect specifies which elements to exclude from the source sequence. In the following example, only those `customers` who have an address in London are returned.

```
var queryLondonCustomers = from cust in customers
                           where cust.City == "London"
                           select cust;
```

You can use the familiar C# logical `AND` and `OR` operators to apply as many filter expressions as necessary in the `where` clause. For example, to return only customers from "London" `AND` whose name is "Devon" you would write the following code:

```
where cust.City=="London" && cust.Name == "Devon"
```

To return customers from London or Paris, you would write the following code:

```
where cust.City == "London" || cust.City == "Paris"
```

For more information, see where clause.

Ordering

Often it is convenient to sort the returned data. The `orderby` clause will cause the elements in the returned sequence to be sorted according to the default comparer for the type being sorted. For example, the following query can be extended to sort the results based on the `Name` property. Because `Name` is a string, the default comparer performs an alphabetical sort from A to Z.

```
var queryLondonCustomers3 =
    from cust in customers
    where cust.City == "London"
    orderby cust.Name ascending
    select cust;
```

To order the results in reverse order, from Z to A, use the `orderby…descending` clause.

For more information, see orderby clause.

Grouping

The `group` clause enables you to group your results based on a key that you specify. For example you could specify that the results should be grouped by the `City` so that all customers from London or Paris are in individual groups. In this case, `cust.City` is the key.

```
// queryCustomersByCity is an IEnumerable<IGrouping<string, Customer>>
  var queryCustomersByCity =
      from cust in customers
      group cust by cust.City;

  // customerGroup is an IGrouping<string, Customer>
  foreach (var customerGroup in queryCustomersByCity)
  {
      Console.WriteLine(customerGroup.Key);
      foreach (Customer customer in customerGroup)
      {
          Console.WriteLine("    {0}", customer.Name);
      }
  }
```

When you end a query with a `group` clause, your results take the form of a list of lists. Each element in the list is an object that has a `Key` member and a list of elements that are grouped under that key. When you iterate over a query that produces a sequence of groups, you must use a nested `foreach` loop. The outer loop iterates over each group, and the inner loop iterates over each group's members.

If you must refer to the results of a group operation, you can use the `into` keyword to create an identifier that can be queried further. The following query returns only those groups that contain more than two customers:

```
// custQuery is an IEnumerable<IGrouping<string, Customer>>
var custQuery =
    from cust in customers
    group cust by cust.City into custGroup
    where custGroup.Count() > 2
    orderby custGroup.Key
    select custGroup;
```

For more information, see group clause.

Joining

Join operations create associations between sequences that are not explicitly modeled in the data sources. For example you can perform a join to find all the customers and distributors who have the same location. In LINQ the `join` clause always works against object collections instead of database tables directly.

```
var innerJoinQuery =
    from cust in customers
    join dist in distributors on cust.City equals dist.City
    select new { CustomerName = cust.Name, DistributorName = dist.Name };
```

In LINQ you do not have to use `join` as often as you do in SQL because foreign keys in LINQ are represented in the object model as properties that hold a collection of items. For example, a `Customer` object contains a collection of `Order` objects. Rather than performing a join, you access the orders by using dot notation:

```
from order in Customer.Orders...
```

For more information, see join clause.

Selecting (Projections)

The `select` clause produces the results of the query and specifies the "shape" or type of each returned element. For example, you can specify whether your results will consist of complete `Customer` objects, just one member, a subset of members, or some completely different result type based on a computation or new object creation. When the `select` clause produces something other than a copy of the source element, the operation is called a *projection*. The use of projections to transform data is a powerful capability of LINQ query expressions. For more information, see Data Transformations with LINQ (C#) and select clause.

See also

- Getting Started with LINQ in C#
- LINQ Query Expressions
- Walkthrough: Writing Queries in C#
- Query Keywords (LINQ)
- Anonymous Types

Data Transformations with LINQ (C#)

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Language-Integrated Query (LINQ) is not only about retrieving data. It is also a powerful tool for transforming data. By using a LINQ query, you can use a source sequence as input and modify it in many ways to create a new output sequence. You can modify the sequence itself without modifying the elements themselves by sorting and grouping. But perhaps the most powerful feature of LINQ queries is the ability to create new types. This is accomplished in the select clause. For example, you can perform the following tasks:

- Merge multiple input sequences into a single output sequence that has a new type.
- Create output sequences whose elements consist of only one or several properties of each element in the source sequence.
- Create output sequences whose elements consist of the results of operations performed on the source data.
- Create output sequences in a different format. For example, you can transform data from SQL rows or text files into XML.

These are just several examples. Of course, these transformations can be combined in various ways in the same query. Furthermore, the output sequence of one query can be used as the input sequence for a new query.

Joining Multiple Inputs into One Output Sequence

You can use a LINQ query to create an output sequence that contains elements from more than one input sequence. The following example shows how to combine two in-memory data structures, but the same principles can be applied to combine data from XML or SQL or DataSet sources. Assume the following two class types:

```
class Student
{
    public string First { get; set; }
    public string Last {get; set;}
    public int ID { get; set; }
    public string Street { get; set; }
    public string City { get; set; }
    public List<int> Scores;
}

class Teacher
{
    public string First { get; set; }
    public string Last { get; set; }
    public int ID { get; set; }
    public string City { get; set; }
}
```

The following example shows the query:

```
class DataTransformations
{
    static void Main()
    {
        // Create the first data source.
        List<Student> students = new List<Student>()
        {
            new Student { First="Svetlana",
                Last="Omelchenko",
                ID=111,
                Street="123 Main Street",
                City="Seattle",
                Scores= new List<int> { 97, 92, 81, 60 } },
            new Student { First="Claire",
                Last="O’Donnell",
                ID=112,
                Street="124 Main Street",
                City="Redmond",
                Scores= new List<int> { 75, 84, 91, 39 } },
            new Student { First="Sven",
                Last="Mortensen",
                ID=113,
                Street="125 Main Street",
                City="Lake City",
                Scores= new List<int> { 88, 94, 65, 91 } },
        };

        // Create the second data source.
        List<Teacher> teachers = new List<Teacher>()
        {
            new Teacher { First="Ann", Last="Beebe", ID=945, City="Seattle" },
            new Teacher { First="Alex", Last="Robinson", ID=956, City="Redmond" },
            new Teacher { First="Michiyo", Last="Sato", ID=972, City="Tacoma" }
        };

        // Create the query.
        var peopleInSeattle = (from student in students
                    where student.City == "Seattle"
                    select student.Last)
                    .Concat(from teacher in teachers
                            where teacher.City == "Seattle"
                            select teacher.Last);

        Console.WriteLine("The following students and teachers live in Seattle:");
        // Execute the query.
        foreach (var person in peopleInSeattle)
        {
            Console.WriteLine(person);
        }

        Console.WriteLine("Press any key to exit.");
        Console.ReadKey();
    }
}
/* Output:
    The following students and teachers live in Seattle:
    Omelchenko
    Beebe
 */
```

For more information, see join clause and select clause.

Selecting a Subset of each Source Element

There are two primary ways to select a subset of each element in the source sequence:

1. To select just one member of the source element, use the dot operation. In the following example, assume that a `Customer` object contains several public properties including a string named `City`. When executed, this query will produce an output sequence of strings.

   ```
   var query = from cust in Customers
               select cust.City;
   ```

2. To create elements that contain more than one property from the source element, you can use an object initializer with either a named object or an anonymous type. The following example shows the use of an anonymous type to encapsulate two properties from each `Customer` element:

   ```
   var query = from cust in Customer
               select new {Name = cust.Name, City = cust.City};
   ```

For more information, see Object and Collection Initializers and Anonymous Types.

Transforming in-Memory Objects into XML

LINQ queries make it easy to transform data between in-memory data structures, SQL databases, ADO.NET Datasets and XML streams or documents. The following example transforms objects in an in-memory data structure into XML elements.

```
class XMLTransform
{
    static void Main()
    {
        // Create the data source by using a collection initializer.
        // The Student class was defined previously in this topic.
        List<Student> students = new List<Student>()
        {
            new Student {First="Svetlana", Last="Omelchenko", ID=111, Scores = new List<int>{97, 92, 81, 60}},
            new Student {First="Claire", Last="O’Donnell", ID=112, Scores = new List<int>{75, 84, 91, 39}},
            new Student {First="Sven", Last="Mortensen", ID=113, Scores = new List<int>{88, 94, 65, 91}},
        };

        // Create the query.
        var studentsToXML = new XElement("Root",
            from student in students
            let scores = string.Join(",", student.Scores)
            select new XElement("student",
                       new XElement("First", student.First),
                       new XElement("Last", student.Last),
                       new XElement("Scores", scores)
                   ) // end "student"
               ); // end "Root"

        // Execute the query.
        Console.WriteLine(studentsToXML);

        // Keep the console open in debug mode.
        Console.WriteLine("Press any key to exit.");
        Console.ReadKey();
    }
}
```

The code produces the following XML output:

```
<Root>
  <student>
    <First>Svetlana</First>
    <Last>Omelchenko</Last>
    <Scores>97,92,81,60</Scores>
  </student>
  <student>
    <First>Claire</First>
    <Last>O'Donnell</Last>
    <Scores>75,84,91,39</Scores>
  </student>
  <student>
    <First>Sven</First>
    <Last>Mortensen</Last>
    <Scores>88,94,65,91</Scores>
  </student>
</Root>
```

For more information, see Creating XML Trees in C# (LINQ to XML).

Performing Operations on Source Elements

An output sequence might not contain any elements or element properties from the source sequence. The output might instead be a sequence of values that is computed by using the source elements as input arguments. The following simple query, when it is executed, outputs a sequence of strings whose values represent a calculation based on the source sequence of elements of type `double`.

NOTE

Calling methods in query expressions is not supported if the query will be translated into some other domain. For example, you cannot call an ordinary C# method in LINQ to SQL because SQL Server has no context for it. However, you can map stored procedures to methods and call those. For more information, see Stored Procedures.

```
class FormatQuery
{
    static void Main()
    {
        // Data source.
        double[] radii = { 1, 2, 3 };

        // Query.
        IEnumerable<string> query =
            from rad in radii
            select $"Area = {rad * rad * Math.PI:F2}";

        // Query execution.
        foreach (string s in query)
            Console.WriteLine(s);

        // Keep the console open in debug mode.
        Console.WriteLine("Press any key to exit.");
        Console.ReadKey();
    }
}
/* Output:
    Area = 3.14
    Area = 12.57
    Area = 28.27
*/
```

See also

- Language-Integrated Query (LINQ) (C#)
- LINQ to SQL
- LINQ to DataSet
- LINQ to XML (C#)
- LINQ Query Expressions
- select clause

Type Relationships in LINQ Query Operations (C#)

1/23/2019 • 2 minutes to read • Edit Online

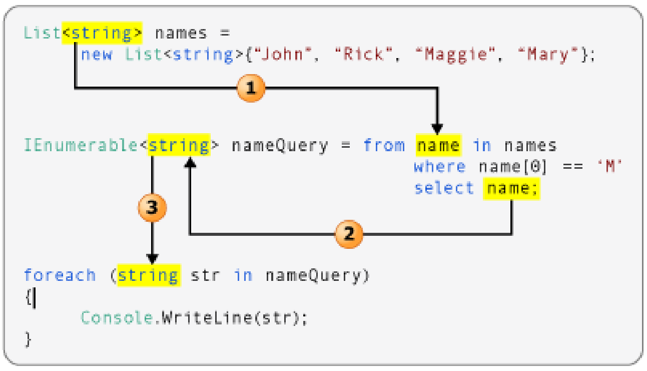
To write queries effectively, you should understand how types of the variables in a complete query operation all relate to each other. If you understand these relationships you will more easily comprehend the LINQ samples and code examples in the documentation. Furthermore, you will understand what occurs behind the scenes when variables are implicitly typed by using `var`.

LINQ query operations are strongly typed in the data source, in the query itself, and in the query execution. The type of the variables in the query must be compatible with the type of the elements in the data source and with the type of the iteration variable in the `foreach` statement. This strong typing guarantees that type errors are caught at compile time when they can be corrected before users encounter them.

In order to demonstrate these type relationships, most of the examples that follow use explicit typing for all variables. The last example shows how the same principles apply even when you use implicit typing by using var.

Queries that do not Transform the Source Data

The following illustration shows a LINQ to Objects query operation that performs no transformations on the data. The source contains a sequence of strings and the query output is also a sequence of strings.

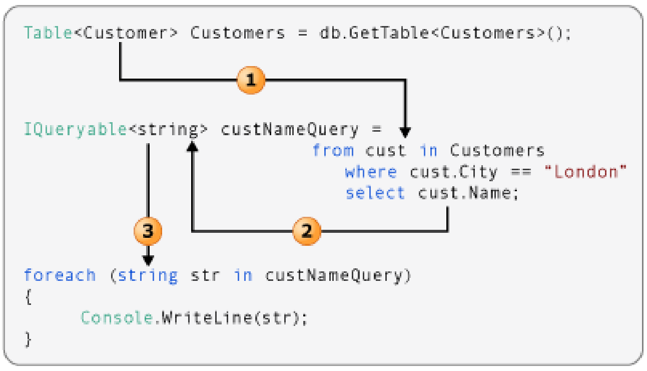


```
List<string> names =
    new List<string>{"John", "Rick", "Maggie", "Mary"};

IEnumerable<string> nameQuery = from name in names
                                where name[0] == 'M'
                                select name;

foreach (string str in nameQuery)
{
    Console.WriteLine(str);
}
```

1. The type argument of the data source determines the type of the range variable.
2. The type of the object that is selected determines the type of the query variable. Here `name` is a string. Therefore, the query variable is an `IEnumerable<string>`.
3. The query variable is iterated over in the `foreach` statement. Because the query variable is a sequence of strings, the iteration variable is also a string.

Queries that Transform the Source Data

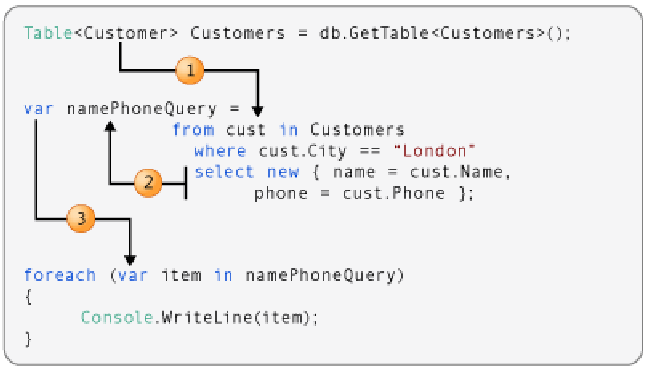
The following illustration shows a LINQ to SQL query operation that performs a simple transformation on the data. The query takes a sequence of `Customer` objects as input, and selects only the `Name` property in the result. Because `Name` is a string, the query produces a sequence of strings as output.



```
Table<Customer> Customers = db.GetTable<Customers>();

IQueryable<string> custNameQuery =
                          from cust in Customers
                             where cust.City == "London"
                             select cust.Name;

foreach (string str in custNameQuery)
{
     Console.WriteLine(str);
}
```

1. The type argument of the data source determines the type of the range variable.
2. The `select` statement returns the `Name` property instead of the complete `Customer` object. Because `Name` is a string, the type argument of `custNameQuery` is `string`, not `Customer`.
3. Because `custNameQuery` is a sequence of strings, the `foreach` loop's iteration variable must also be a `string`.

The following illustration shows a slightly more complex transformation. The `select` statement returns an anonymous type that captures just two members of the original `Customer` object.

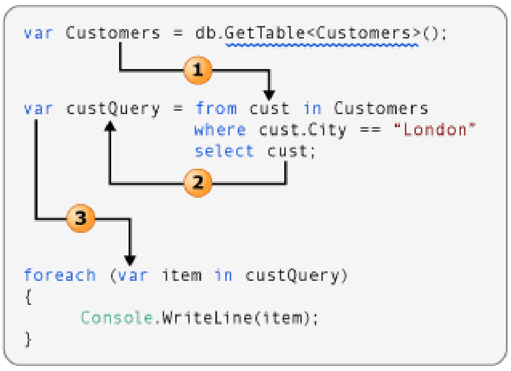


```
Table<Customer> Customers = db.GetTable<Customers>();

var namePhoneQuery =
             from cust in Customers
               where cust.City == "London"
               select new { name = cust.Name,
                    phone = cust.Phone };

foreach (var item in namePhoneQuery)
{
     Console.WriteLine(item);
}
```

1. The type argument of the data source is always the type of the range variable in the query.
2. Because the `select` statement produces an anonymous type, the query variable must be implicitly typed by using `var`.
3. Because the type of the query variable is implicit, the iteration variable in the `foreach` loop must also be implicit.

Letting the compiler infer type information

Although you should understand the type relationships in a query operation, you have the option to let the compiler do all the work for you. The keyword var can be used for any local variable in a query operation. The following illustration is similar to example number 2 that was discussed earlier. However, the compiler supplies the strong type for each variable in the query operation.



```
var Customers = db.GetTable<Customers>();

var custQuery = from cust in Customers
               where cust.City == "London"
               select cust;

foreach (var item in custQuery)
{
     Console.WriteLine(item);
}
```

For more information about `var`, see Implicitly Typed Local Variables.

See also

- Getting Started with LINQ in C#

Query Syntax and Method Syntax in LINQ (C#)

1/23/2019 • 4 minutes to read • Edit Online

Most queries in the introductory Language Integrated Query (LINQ) documentation are written by using the LINQ declarative query syntax. However, the query syntax must be translated into method calls for the .NET common language runtime (CLR) when the code is compiled. These method calls invoke the standard query operators, which have names such as `Where`, `Select`, `GroupBy`, `Join`, `Max`, and `Average`. You can call them directly by using method syntax instead of query syntax.

Query syntax and method syntax are semantically identical, but many people find query syntax simpler and easier to read. Some queries must be expressed as method calls. For example, you must use a method call to express a query that retrieves the number of elements that match a specified condition. You also must use a method call for a query that retrieves the element that has the maximum value in a source sequence. The reference documentation for the standard query operators in the System.Linq namespace generally uses method syntax. Therefore, even when getting started writing LINQ queries, it is useful to be familiar with how to use method syntax in queries and in query expressions themselves.

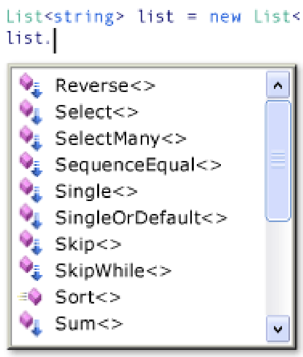
Standard Query Operator Extension Methods

The following example shows a simple *query expression* and the semantically equivalent query written as a *method-based query*.

```
class QueryVMethodSyntax
{
    static void Main()
    {
        int[] numbers = { 5, 10, 8, 3, 6, 12};

        //Query syntax:
        IEnumerable<int> numQuery1 =
            from num in numbers
            where num % 2 == 0
            orderby num
            select num;

        //Method syntax:
        IEnumerable<int> numQuery2 = numbers.Where(num => num % 2 == 0).OrderBy(n => n);

        foreach (int i in numQuery1)
        {
            Console.Write(i + " ");
        }
        Console.WriteLine(System.Environment.NewLine);
        foreach (int i in numQuery2)
        {
            Console.Write(i + " ");
        }

        // Keep the console open in debug mode.
        Console.WriteLine(System.Environment.NewLine);
        Console.WriteLine("Press any key to exit");
        Console.ReadKey();
    }
}
/*
    Output:
    6 8 10 12
    6 8 10 12
 */
```

The output from the two examples is identical. You can see that the type of the query variable is the same in both forms: IEnumerable<T>.

To understand the method-based query, let's examine it more closely. On the right side of the expression, notice that the `where` clause is now expressed as an instance method on the `numbers` object, which as you will recall has a type of `IEnumerable<int>`. If you are familiar with the generic IEnumerable<T> interface, you know that it does not have a `Where` method. However, if you invoke the IntelliSense completion list in the Visual Studio IDE, you will see not only a `Where` method, but many other methods such as `Select`, `SelectMany`, `Join`, and `Orderby`. These are all the standard query operators.



```
List<string> list = new List<string>();
list.
```

Although it looks as if IEnumerable<T> has been redefined to include these additional methods, in fact this is not the case. The standard query operators are implemented as a new kind of method called *extension methods*. Extensions methods "extend" an existing type; they can be called as if they were instance methods on the type. The standard query operators extend IEnumerable<T> and that is why you can write `numbers.Where(...)`.

To get started using LINQ, all that you really have to know about extension methods is how to bring them into scope in your application by using the correct `using` directives. From your application's point of view, an extension method and a regular instance method are the same.

For more information about extension methods, see Extension Methods. For more information about standard query operators, see Standard Query Operators Overview (C#). Some LINQ providers, such as LINQ to SQL and LINQ to XML, implement their own standard query operators and additional extension methods for other types besides IEnumerable<T>.

Lambda Expressions

In the previous example, notice that the conditional expression (`num % 2 == 0`) is passed as an in-line argument to the `Where` method: `Where(num => num % 2 == 0).` This inline expression is called a lambda expression. It is a convenient way to write code that would otherwise have to be written in more cumbersome form as an anonymous method or a generic delegate or an expression tree. In C# `=>` is the lambda operator, which is read as "goes to". The `num` on the left of the operator is the input variable which corresponds to `num` in the query expression. The compiler can infer the type of `num` because it knows that `numbers` is a generic IEnumerable<T> type. The body of the lambda is just the same as the expression in query syntax or in any other C# expression or statement; it can include method calls and other complex logic. The "return value" is just the expression result.

To get started using LINQ, you do not have to use lambdas extensively. However, certain queries can only be expressed in method syntax and some of those require lambda expressions. After you become more familiar with lambdas, you will find that they are a powerful and flexible tool in your LINQ toolbox. For more information, see Lambda Expressions.

Composability of Queries

In the previous code example, note that the `OrderBy` method is invoked by using the dot operator on the call to `Where`. `Where` produces a filtered sequence, and then `Orderby` operates on that sequence by sorting it. Because queries return an `IEnumerable`, you compose them in method syntax by chaining the method calls together. This is what the compiler does behind the scenes when you write queries by using query syntax. And because a query variable does not store the results of the query, you can modify it or use it as the basis for a new query at any time, even after it has been executed.

See also

- Getting Started with LINQ in C#

C# Features That Support LINQ

1/23/2019 • 3 minutes to read • Edit Online

The following section introduces new language constructs introduced in C# 3.0. Although these new features are all used to a degree with LINQ queries, they are not limited to LINQ and can be used in any context where you find them useful.

Query Expressions

Query expressions use a declarative syntax similar to SQL or XQuery to query over IEnumerable collections. At compile time query syntax is converted to method calls to a LINQ provider's implementation of the standard query operator extension methods. Applications control the standard query operators that are in scope by specifying the appropriate namespace with a `using` directive. The following query expression takes an array of strings, groups them according to the first character in the string, and orders the groups.

```
var query = from str in stringArray
            group str by str[0] into stringGroup
            orderby stringGroup.Key
            select stringGroup;
```

For more information, see LINQ Query Expressions.

Implicitly Typed Variables (var)

Instead of explicitly specifying a type when you declare and initialize a variable, you can use the var modifier to instruct the compiler to infer and assign the type, as shown here:

```
var number = 5;
var name = "Virginia";
var query = from str in stringArray
            where str[0] == 'm'
            select str;
```

Variables declared as `var` are just as strongly-typed as variables whose type you specify explicitly. The use of `var` makes it possible to create anonymous types, but it can be used only for local variables. Arrays can also be declared with implicit typing.

For more information, see Implicitly Typed Local Variables.

Object and Collection Initializers

Object and collection initializers make it possible to initialize objects without explicitly calling a constructor for the object. Initializers are typically used in query expressions when they project the source data into a new data type. Assuming a class named `Customer` with public `Name` and `Phone` properties, the object initializer can be used as in the following code:

```
Customer cust = new Customer { Name = "Mike", Phone = "555-1212" };
```

Continuing with our `Customer` class, assume that there is a data source called `IncomingOrders`, and that for each order with a large `OrderSize`, we would like to create a new `Customer` based off of that order. A LINQ query can be executed on this data source and use object initialization to fill a collection:

```
var newLargeOrderCustomers = from o in IncomingOrders
                            where o.OrderSize > 5
                            select new Customer { Name = o.Name, Phone = o.Phone };
```

The data source may have more properties lying under the hood than the `Customer` class such as `OrderSize`, but with object initialization, the data returned from the query is molded into the desired data type; we choose the data that is relevant to our class. As a result, we now have an `IEnumerable` filled with the new `Customer`s we wanted. The above can also be written in LINQ's method syntax:

```
var newLargeOrderCustomers = IncomingOrders.Where(x => x.OrderSize > 5).Select(y => new Customer { Name = 
y.Name, Phone = y.Phone });
```

For more information, see:

- Object and Collection Initializers
- Query Expression Syntax for Standard Query Operators

Anonymous Types

An anonymous type is constructed by the compiler and the type name is only available to the compiler. Anonymous types provide a convenient way to group a set of properties temporarily in a query result without having to define a separate named type. Anonymous types are initialized with a new expression and an object initializer, as shown here:

```
select new {name = cust.Name, phone = cust.Phone};
```

For more information, see Anonymous Types.

Extension Methods

An extension method is a static method that can be associated with a type, so that it can be called as if it were an instance method on the type. This feature enables you to, in effect, "add" new methods to existing types without actually modifying them. The standard query operators are a set of extension methods that provide LINQ query functionality for any type that implements IEnumerable<T>.

For more information, see Extension Methods.

Lambda Expressions

A lambda expression is an inline function that uses the => operator to separate input parameters from the function body and can be converted at compile time to a delegate or an expression tree. In LINQ programming, you will encounter lambda expressions when you make direct method calls to the standard query operators.

For more information, see:

- Anonymous Functions
- Lambda Expressions
- Expression Trees (C#)

See also

- Language-Integrated Query (LINQ) (C#)

Walkthrough: Writing Queries in C# (LINQ)

1/23/2019 • 10 minutes to read • Edit Online

This walkthrough demonstrates the C# language features that are used to write LINQ query expressions.

Create a C# Project

NOTE

The following instructions are for Visual Studio. If you are using a different development environment, create a console project with a reference to System.Core.dll and a `using` directive for the System.Linq namespace.

To create a project in Visual Studio

1. Start Visual Studio.
2. On the menu bar, choose **File**, **New**, **Project**.

   The **New Project** dialog box opens.
3. Expand **Installed**, expand **Templates**, expand **Visual C#**, and then choose **Console Application**.
4. In the **Name** text box, enter a different name or accept the default name, and then choose the **OK** button.

   The new project appears in **Solution Explorer**.
5. Notice that your project has a reference to System.Core.dll and a `using` directive for the System.Linq namespace.

Create an in-Memory Data Source

The data source for the queries is a simple list of `Student` objects. Each `Student` record has a first name, last name, and an array of integers that represents their test scores in the class. Copy this code into your project. Note the following characteristics:

- The `Student` class consists of auto-implemented properties.
- Each student in the list is initialized with an object initializer.
- The list itself is initialized with a collection initializer.

This whole data structure will be initialized and instantiated without explicit calls to any constructor or explicit member access. For more information about these new features, see Auto-Implemented Properties and Object and Collection Initializers.

To add the data source

- Add the `Student` class and the initialized list of students to the `Program` class in your project.

```
public class Student
{
    public string First { get; set; }
    public string Last { get; set; }
    public int ID { get; set; }
    public List<int> Scores;
}

// Create a data source by using a collection initializer.
static List<Student> students = new List<Student>
{
    new Student {First="Svetlana", Last="Omelchenko", ID=111, Scores= new List<int> {97, 92, 81, 60}},
    new Student {First="Claire", Last="O'Donnell", ID=112, Scores= new List<int> {75, 84, 91, 39}},
    new Student {First="Sven", Last="Mortensen", ID=113, Scores= new List<int> {88, 94, 65, 91}},
    new Student {First="Cesar", Last="Garcia", ID=114, Scores= new List<int> {97, 89, 85, 82}},
    new Student {First="Debra", Last="Garcia", ID=115, Scores= new List<int> {35, 72, 91, 70}},
    new Student {First="Fadi", Last="Fakhouri", ID=116, Scores= new List<int> {99, 86, 90, 94}},
    new Student {First="Hanying", Last="Feng", ID=117, Scores= new List<int> {93, 92, 80, 87}},
    new Student {First="Hugo", Last="Garcia", ID=118, Scores= new List<int> {92, 90, 83, 78}},
    new Student {First="Lance", Last="Tucker", ID=119, Scores= new List<int> {68, 79, 88, 92}},
    new Student {First="Terry", Last="Adams", ID=120, Scores= new List<int> {99, 82, 81, 79}},
    new Student {First="Eugene", Last="Zabokritski", ID=121, Scores= new List<int> {96, 85, 91, 60}},
    new Student {First="Michael", Last="Tucker", ID=122, Scores= new List<int> {94, 92, 91, 91}}
};
```

To add a new Student to the Students list

1. Add a new `Student` to the `Students` list and use a name and test scores of your choice. Try typing all the new student information in order to better learn the syntax for the object initializer.

Create the Query

To create a simple query

- In the application's `Main` method, create a simple query that, when it is executed, will produce a list of all students whose score on the first test was greater than 90. Note that because the whole `Student` object is selected, the type of the query is `IEnumerable<Student>`. Although the code could also use implicit typing by using the var keyword, explicit typing is used to clearly illustrate results. (For more information about `var`, see Implicitly Typed Local Variables.)

  Note also that the query's range variable, `student`, serves as a reference to each `Student` in the source, providing member access for each object.

```
// Create the query.
// The first line could also be written as "var studentQuery ="
IEnumerable<Student> studentQuery =
    from student in students
    where student.Scores[0] > 90
    select student;
```

Execute the Query

To execute the query

1. Now write the `foreach` loop that will cause the query to execute. Note the following about the code:

   - Each element in the returned sequence is accessed through the iteration variable in the `foreach` loop.

   - The type of this variable is `Student`, and the type of the query variable is compatible, `IEnumerable<Student>`.

2. After you have added this code, build and run the application to see the results in the **Console** window.

```
// Execute the query.
// var could be used here also.
foreach (Student student in studentQuery)
{
    Console.WriteLine("{0}, {1}", student.Last, student.First);
}

// Output:
// Omelchenko, Svetlana
// Garcia, Cesar
// Fakhouri, Fadi
// Feng, Hanying
// Garcia, Hugo
// Adams, Terry
// Zabokritski, Eugene
// Tucker, Michael
```

To add another filter condition

1. You can combine multiple Boolean conditions in the `where` clause in order to further refine a query. The following code adds a condition so that the query returns those students whose first score was over 90 and whose last score was less than 80. The `where` clause should resemble the following code.

   ```
   where student.Scores[0] > 90 && student.Scores[3] < 80
   ```

   For more information, see where clause.

Modify the Query

To order the results

1. It will be easier to scan the results if they are in some kind of order. You can order the returned sequence by any accessible field in the source elements. For example, the following `orderby` clause orders the results in alphabetical order from A to Z according to the last name of each student. Add the following `orderby` clause to your query, right after the `where` statement and before the `select` statement:

   ```
   orderby student.Last ascending
   ```

2. Now change the `orderby` clause so that it orders the results in reverse order according to the score on the first test, from the highest score to the lowest score.

   ```
   orderby student.Scores[0] descending
   ```

3. Change the `WriteLine` format string so that you can see the scores:

   ```
   Console.WriteLine("{0}, {1} {2}", student.Last, student.First, student.Scores[0]);
   ```

   For more information, see orderby clause.

To group the results

1. Grouping is a powerful capability in query expressions. A query with a group clause produces a sequence of groups, and each group itself contains a `Key` and a sequence that consists of all the members of that group. The following new query groups the students by using the first letter of their last name as the key.

```
// studentQuery2 is an IEnumerable<IGrouping<char, Student>>
var studentQuery2 =
    from student in students
    group student by student.Last[0];
```

2. Note that the type of the query has now changed. It now produces a sequence of groups that have a `char` type as a key, and a sequence of `Student` objects. Because the type of the query has changed, the following code changes the `foreach` execution loop also:

```
// studentGroup is a IGrouping<char, Student>
foreach (var studentGroup in studentQuery2)
{
    Console.WriteLine(studentGroup.Key);
    foreach (Student student in studentGroup)
    {
        Console.WriteLine("   {0}, {1}",
                  student.Last, student.First);
    }
}

// Output:
// O
//   Omelchenko, Svetlana
//   O'Donnell, Claire
// M
//   Mortensen, Sven
// G
//   Garcia, Cesar
//   Garcia, Debra
//   Garcia, Hugo
// F
//   Fakhouri, Fadi
//   Feng, Hanying
// T
//   Tucker, Lance
//   Tucker, Michael
// A
//   Adams, Terry
// Z
//   Zabokritski, Eugene
```

3. Run the application and view the results in the **Console** window.

   For more information, see group clause.

To make the variables implicitly typed

1. Explicitly coding `IEnumerables` of `IGroupings` can quickly become tedious. You can write the same query and `foreach` loop much more conveniently by using `var`. The `var` keyword does not change the types of your objects; it just instructs the compiler to infer the types. Change the type of `studentQuery` and the iteration variable `group` to `var` and rerun the query. Note that in the inner `foreach` loop, the iteration variable is still typed as `Student`, and the query works just as before. Change the `s` iteration variable to `var` and run the query again. You see that you get exactly the same results.

```
var studentQuery3 =
    from student in students
    group student by student.Last[0];

foreach (var groupOfStudents in studentQuery3)
{
    Console.WriteLine(groupOfStudents.Key);
    foreach (var student in groupOfStudents)
    {
        Console.WriteLine("   {0}, {1}",
            student.Last, student.First);
    }
}

// Output:
// O
//   Omelchenko, Svetlana
//   O'Donnell, Claire
// M
//   Mortensen, Sven
// G
//   Garcia, Cesar
//   Garcia, Debra
//   Garcia, Hugo
// F
//   Fakhouri, Fadi
//   Feng, Hanying
// T
//   Tucker, Lance
//   Tucker, Michael
// A
//   Adams, Terry
// Z
//   Zabokritski, Eugene
```

For more information about var, see Implicitly Typed Local Variables.

To order the groups by their key value

1. When you run the previous query, you notice that the groups are not in alphabetical order. To change this, you must provide an `orderby` clause after the `group` clause. But to use an `orderby` clause, you first need an identifier that serves as a reference to the groups created by the `group` clause. You provide the identifier by using the `into` keyword, as follows:

```
var studentQuery4 =
    from student in students
    group student by student.Last[0] into studentGroup
    orderby studentGroup.Key
    select studentGroup;

foreach (var groupOfStudents in studentQuery4)
{
    Console.WriteLine(groupOfStudents.Key);
    foreach (var student in groupOfStudents)
    {
        Console.WriteLine("   {0}, {1}",
            student.Last, student.First);
    }
}

// Output:
//A
//   Adams, Terry
//F
//   Fakhouri, Fadi
//   Feng, Hanying
//G
//   Garcia, Cesar
//   Garcia, Debra
//   Garcia, Hugo
//M
//   Mortensen, Sven
//O
//   Omelchenko, Svetlana
//   O'Donnell, Claire
//T
//   Tucker, Lance
//   Tucker, Michael
//Z
//   Zabokritski, Eugene
```

When you run this query, you will see the groups are now sorted in alphabetical order.

To introduce an identifier by using let

1. You can use the `let` keyword to introduce an identifier for any expression result in the query expression. This identifier can be a convenience, as in the following example, or it can enhance performance by storing the results of an expression so that it does not have to be calculated multiple times.

```
// studentQuery5 is an IEnumerable<string>
// This query returns those students whose
// first test score was higher than their
// average score.
var studentQuery5 =
    from student in students
    let totalScore = student.Scores[0] + student.Scores[1] +
        student.Scores[2] + student.Scores[3]
    where totalScore / 4 < student.Scores[0]
    select student.Last + " " + student.First;

foreach (string s in studentQuery5)
{
    Console.WriteLine(s);
}

// Output:
// Omelchenko Svetlana
// O'Donnell Claire
// Mortensen Sven
// Garcia Cesar
// Fakhouri Fadi
// Feng Hanying
// Garcia Hugo
// Adams Terry
// Zabokritski Eugene
// Tucker Michael
```

For more information, see let clause.

To use method syntax in a query expression

1. As described in Query Syntax and Method Syntax in LINQ, some query operations can only be expressed by using method syntax. The following code calculates the total score for each `Student` in the source sequence, and then calls the `Average()` method on the results of that query to calculate the average score of the class.

```
var studentQuery6 =
    from student in students
    let totalScore = student.Scores[0] + student.Scores[1] +
        student.Scores[2] + student.Scores[3]
    select totalScore;

double averageScore = studentQuery6.Average();
Console.WriteLine("Class average score = {0}", averageScore);

// Output:
// Class average score = 334.166666666667
```

To transform or project in the select clause

1. It is very common for a query to produce a sequence whose elements differ from the elements in the source sequences. Delete or comment out your previous query and execution loop, and replace it with the following code. Note that the query returns a sequence of strings (not `Students`), and this fact is reflected in the `foreach` loop.

```
IEnumerable<string> studentQuery7 =
    from student in students
    where student.Last == "Garcia"
    select student.First;

Console.WriteLine("The Garcias in the class are:");
foreach (string s in studentQuery7)
{
    Console.WriteLine(s);
}

// Output:
// The Garcias in the class are:
// Cesar
// Debra
// Hugo
```

2. Code earlier in this walkthrough indicated that the average class score is approximately 334. To produce a sequence of `Students` whose total score is greater than the class average, together with their `Student ID`, you can use an anonymous type in the `select` statement:

```
var studentQuery8 =
    from student in students
    let x = student.Scores[0] + student.Scores[1] +
        student.Scores[2] + student.Scores[3]
    where x > averageScore
    select new { id = student.ID, score = x };

foreach (var item in studentQuery8)
{
    Console.WriteLine("Student ID: {0}, Score: {1}", item.id, item.score);
}

// Output:
// Student ID: 113, Score: 338
// Student ID: 114, Score: 353
// Student ID: 116, Score: 369
// Student ID: 117, Score: 352
// Student ID: 118, Score: 343
// Student ID: 120, Score: 341
// Student ID: 122, Score: 368
```

Next Steps

After you are familiar with the basic aspects of working with queries in C#, you are ready to read the documentation and samples for the specific type of LINQ provider you are interested in:

LINQ to SQL

LINQ to DataSet

LINQ to XML (C#)

LINQ to Objects (C#)

See also

- Language-Integrated Query (LINQ) (C#)
- Getting Started with LINQ in C#
- LINQ Query Expressions

Standard Query Operators Overview (C#)

1/23/2019 • 3 minutes to read • Edit Online

The *standard query operators* are the methods that form the LINQ pattern. Most of these methods operate on sequences, where a sequence is an object whose type implements the IEnumerable<T> interface or the IQueryable<T> interface. The standard query operators provide query capabilities including filtering, projection, aggregation, sorting and more.

There are two sets of LINQ standard query operators, one that operates on objects of type IEnumerable<T> and the other that operates on objects of type IQueryable<T>. The methods that make up each set are static members of the Enumerable and Queryable classes, respectively. They are defined as *extension methods* of the type that they operate on. This means that they can be called by using either static method syntax or instance method syntax.

In addition, several standard query operator methods operate on types other than those based on IEnumerable<T> or IQueryable<T>. The Enumerable type defines two such methods that both operate on objects of type IEnumerable. These methods, Cast<TResult>(IEnumerable) and OfType<TResult>(IEnumerable), let you enable a non-parameterized, or non-generic, collection to be queried in the LINQ pattern. They do this by creating a strongly-typed collection of objects. The Queryable class defines two similar methods, Cast<TResult>(IQueryable) and OfType<TResult>(IQueryable), that operate on objects of type Queryable.

The standard query operators differ in the timing of their execution, depending on whether they return a singleton value or a sequence of values. Those methods that return a singleton value (for example, Average and Sum) execute immediately. Methods that return a sequence defer the query execution and return an enumerable object.

In the case of the methods that operate on in-memory collections, that is, those methods that extend IEnumerable<T>, the returned enumerable object captures the arguments that were passed to the method. When that object is enumerated, the logic of the query operator is employed and the query results are returned.

In contrast, methods that extend IQueryable<T> do not implement any querying behavior, but build an expression tree that represents the query to be performed. The query processing is handled by the source IQueryable<T> object.

Calls to query methods can be chained together in one query, which enables queries to become arbitrarily complex.

The following code example demonstrates how the standard query operators can be used to obtain information about a sequence.

```
string sentence = "the quick brown fox jumps over the lazy dog";
// Split the string into individual words to create a collection.
string[] words = sentence.Split(' ');

// Using query expression syntax.
var query = from word in words
            group word.ToUpper() by word.Length into gr
            orderby gr.Key
            select new { Length = gr.Key, Words = gr };

// Using method-based query syntax.
var query2 = words.
    GroupBy(w => w.Length, w => w.ToUpper()).
    Select(g => new { Length = g.Key, Words = g }).
    OrderBy(o => o.Length);

foreach (var obj in query)
{
    Console.WriteLine("Words of length {0}:", obj.Length);
    foreach (string word in obj.Words)
        Console.WriteLine(word);
}

// This code example produces the following output:
//
// Words of length 3:
// THE
// FOX
// THE
// DOG
// Words of length 4:
// OVER
// LAZY
// Words of length 5:
// QUICK
// BROWN
// JUMPS
```

Query Expression Syntax

Some of the more frequently used standard query operators have dedicated C# and Visual Basic language keyword syntax that enables them to be called as part of a *query expression*. For more information about standard query operators that have dedicated keywords and their corresponding syntaxes, see Query Expression Syntax for Standard Query Operators (C#).

Extending the Standard Query Operators

You can augment the set of standard query operators by creating domain-specific methods that are appropriate for your target domain or technology. You can also replace the standard query operators with your own implementations that provide additional services such as remote evaluation, query translation, and optimization. See AsEnumerable for an example.

Related Sections

The following links take you to topics that provide additional information about the various standard query operators based on functionality.

Sorting Data (C#)

Set Operations (C#)

Filtering Data (C#)

Quantifier Operations (C#)

Projection Operations (C#)

Partitioning Data (C#)

Join Operations (C#)

Grouping Data (C#)

Generation Operations (C#)

Equality Operations (C#)

Element Operations (C#)

Converting Data Types (C#)

Concatenation Operations (C#)

Aggregation Operations (C#)

See also

- Enumerable
- Queryable
- Introduction to LINQ Queries (C#)
- Query Expression Syntax for Standard Query Operators (C#)
- Classification of Standard Query Operators by Manner of Execution (C#)
- Extension Methods

Query Expression Syntax for Standard Query Operators (C#)

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Some of the more frequently used standard query operators have dedicated C# language keyword syntax that enables them to be called as part of a *query expression*. A query expression is a different, more readable form of expressing a query than its *method-based* equivalent. Query expression clauses are translated into calls to the query methods at compile time.

Query Expression Syntax Table

The following table lists the standard query operators that have equivalent query expression clauses.

METHOD	C# QUERY EXPRESSION SYNTAX
Cast	Use an explicitly typed range variable, for example: `from int i in numbers` (For more information, see from clause.)
GroupBy	`group … by` -or- `group … by … into …` (For more information, see group clause.)
GroupJoin<TOuter,TInner,TKey,TResult>(IEnumerable<TOuter>, IEnumerable<TInner>, Func<TOuter,TKey>, Func<TInner,TKey>, Func<TOuter,IEnumerable<TInner>,TResult>)	`join … in … on … equals … into …` (For more information, see join clause.)
Join<TOuter,TInner,TKey,TResult>(IEnumerable<TOuter>, IEnumerable<TInner>, Func<TOuter,TKey>, Func<TInner,TKey>, Func<TOuter,TInner,TResult>)	`join … in … on … equals …` (For more information, see join clause.)
OrderBy<TSource,TKey>(IEnumerable<TSource>, Func<TSource,TKey>)	`orderby` (For more information, see orderby clause.)
OrderByDescending<TSource,TKey>(IEnumerable<TSource>, Func<TSource,TKey>)	`orderby … descending` (For more information, see orderby clause.)
Select	`select` (For more information, see select clause.)

METHOD	C# QUERY EXPRESSION SYNTAX
SelectMany	Multiple `from` clauses. (For more information, see from clause.)
ThenBy<TSource,TKey>(IOrderedEnumerable<TSource>, Func<TSource,TKey>)	`orderby …, …` (For more information, see orderby clause.)
ThenByDescending<TSource,TKey>(IOrderedEnumerable<TSource>, Func<TSource,TKey>)	`orderby …, … descending` (For more information, see orderby clause.)
Where	`where` (For more information, see where clause.)

See also

- Enumerable
- Queryable
- Standard Query Operators Overview (C#)
- Classification of Standard Query Operators by Manner of Execution (C#)

Classification of Standard Query Operators by Manner of Execution (C#)

1/23/2019 • 2 minutes to read • Edit Online

The LINQ to Objects implementations of the standard query operator methods execute in one of two main ways: immediate or deferred. The query operators that use deferred execution can be additionally divided into two categories: streaming and non-streaming. If you know how the different query operators execute, it may help you understand the results that you get from a given query. This is especially true if the data source is changing or if you are building a query on top of another query. This topic classifies the standard query operators according to their manner of execution.

Manners of Execution

Immediate

Immediate execution means that the data source is read and the operation is performed at the point in the code where the query is declared. All the standard query operators that return a single, non-enumerable result execute immediately.

Deferred

Deferred execution means that the operation is not performed at the point in the code where the query is declared. The operation is performed only when the query variable is enumerated, for example by using a `foreach` statement. This means that the results of executing the query depend on the contents of the data source when the query is executed rather than when the query is defined. If the query variable is enumerated multiple times, the results might differ every time. Almost all the standard query operators whose return type is IEnumerable<T> or IOrderedEnumerable<TElement> execute in a deferred manner.

Query operators that use deferred execution can be additionally classified as streaming or non-streaming.

Streaming

Streaming operators do not have to read all the source data before they yield elements. At the time of execution, a streaming operator performs its operation on each source element as it is read and yields the element if appropriate. A streaming operator continues to read source elements until a result element can be produced. This means that more than one source element might be read to produce one result element.

Non-Streaming

Non-streaming operators must read all the source data before they can yield a result element. Operations such as sorting or grouping fall into this category. At the time of execution, non-streaming query operators read all the source data, put it into a data structure, perform the operation, and yield the resulting elements.

Classification Table

The following table classifies each standard query operator method according to its method of execution.

NOTE

If an operator is marked in two columns, two input sequences are involved in the operation, and each sequence is evaluated differently. In these cases, it is always the first sequence in the parameter list that is evaluated in a deferred, streaming manner.

STANDARD QUERY OPERATOR	RETURN TYPE	IMMEDIATE EXECUTION	DEFERRED STREAMING EXECUTION	DEFERRED NON-STREAMING EXECUTION
Aggregate	TSource	X		
All	Boolean	X		
Any	Boolean	X		
AsEnumerable	IEnumerable<T>		X	
Average	Single numeric value	X		
Cast	IEnumerable<T>		X	
Concat	IEnumerable<T>		X	
Contains	Boolean	X		
Count	Int32	X		
DefaultIfEmpty	IEnumerable<T>		X	
Distinct	IEnumerable<T>		X	
ElementAt	TSource	X		
ElementAtOrDefault	TSource	X		
Empty	IEnumerable<T>	X		
Except	IEnumerable<T>		X	X
First	TSource	X		
FirstOrDefault	TSource	X		
GroupBy	IEnumerable<T>			X
GroupJoin	IEnumerable<T>		X	X
Intersect	IEnumerable<T>		X	X
Join	IEnumerable<T>		X	X
Last	TSource	X		
LastOrDefault	TSource	X		
LongCount	Int64	X		

STANDARD QUERY OPERATOR	RETURN TYPE	IMMEDIATE EXECUTION	DEFERRED STREAMING EXECUTION	DEFERRED NON-STREAMING EXECUTION
Max	Single numeric value, TSource, or TResult	X		
Min	Single numeric value, TSource, or TResult	X		
OfType	IEnumerable<T>		X	
OrderBy	IOrderedEnumerable<TElement>			X
OrderByDescending	IOrderedEnumerable<TElement>			X
Range	IEnumerable<T>		X	
Repeat	IEnumerable<T>		X	
Reverse	IEnumerable<T>			X
Select	IEnumerable<T>		X	
SelectMany	IEnumerable<T>		X	
SequenceEqual	Boolean	X		
Single	TSource	X		
SingleOrDefault	TSource	X		
Skip	IEnumerable<T>		X	
SkipWhile	IEnumerable<T>		X	
Sum	Single numeric value	X		
Take	IEnumerable<T>		X	
TakeWhile	IEnumerable<T>		X	
ThenBy	IOrderedEnumerable<TElement>			X
ThenByDescending	IOrderedEnumerable<TElement>			X
ToArray	TSource array	X		
ToDictionary	Dictionary<TKey,TValue>	X		

STANDARD QUERY OPERATOR	RETURN TYPE	IMMEDIATE EXECUTION	DEFERRED STREAMING EXECUTION	DEFERRED NON-STREAMING EXECUTION
ToList	IList<T>	X		
ToLookup	ILookup<TKey,TElement>	X		
Union	IEnumerable<T>		X	
Where	IEnumerable<T>		X	

See also

- Enumerable
- Standard Query Operators Overview (C#)
- Query Expression Syntax for Standard Query Operators (C#)
- LINQ to Objects (C#)

Sorting Data (C#)

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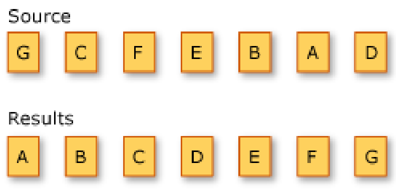
A sorting operation orders the elements of a sequence based on one or more attributes. The first sort criterion performs a primary sort on the elements. By specifying a second sort criterion, you can sort the elements within each primary sort group.

The following illustration shows the results of an alphabetical sort operation on a sequence of characters.



The standard query operator methods that sort data are listed in the following section.

Methods

METHOD NAME	DESCRIPTION	C# QUERY EXPRESSION SYNTAX	MORE INFORMATION
OrderBy	Sorts values in ascending order.	`orderby`	Enumerable.OrderBy Queryable.OrderBy
OrderByDescending	Sorts values in descending order.	`orderby … descending`	Enumerable.OrderByDescending Queryable.OrderByDescending
ThenBy	Performs a secondary sort in ascending order.	`orderby …, …`	Enumerable.ThenBy Queryable.ThenBy
ThenByDescending	Performs a secondary sort in descending order.	`orderby …, … descending`	Enumerable.ThenByDescending Queryable.ThenByDescending
Reverse	Reverses the order of the elements in a collection.	Not applicable.	Enumerable.Reverse Queryable.Reverse

Query Expression Syntax Examples

Primary Sort Examples

Primary Ascending Sort

The following example demonstrates how to use the `orderby` clause in a LINQ query to sort the strings in an array by string length, in ascending order.

```
string[] words = { "the", "quick", "brown", "fox", "jumps" };

IEnumerable<string> query = from word in words
                            orderby word.Length
                            select word;

foreach (string str in query)
    Console.WriteLine(str);

/* This code produces the following output:

    the
    fox
    quick
    brown
    jumps
*/
```

Primary Descending Sort

The next example demonstrates how to use the `orderby descending` clause in a LINQ query to sort the strings by their first letter, in descending order.

```
string[] words = { "the", "quick", "brown", "fox", "jumps" };

IEnumerable<string> query = from word in words
                            orderby word.Substring(0, 1) descending
                            select word;

foreach (string str in query)
    Console.WriteLine(str);

/* This code produces the following output:

    the
    quick
    jumps
    fox
    brown
*/
```

Secondary Sort Examples

Secondary Ascending Sort

The following example demonstrates how to use the `orderby` clause in a LINQ query to perform a primary and secondary sort of the strings in an array. The strings are sorted primarily by length and secondarily by the first letter of the string, both in ascending order.

```
string[] words = { "the", "quick", "brown", "fox", "jumps" };

IEnumerable<string> query = from word in words
                            orderby word.Length, word.Substring(0, 1)
                            select word;

foreach (string str in query)
    Console.WriteLine(str);

/* This code produces the following output:

    fox
    the
    brown
    jumps
    quick
*/
```

Secondary Descending Sort

The next example demonstrates how to use the `orderby descending` clause in a LINQ query to perform a primary sort, in ascending order, and a secondary sort, in descending order. The strings are sorted primarily by length and secondarily by the first letter of the string.

```
string[] words = { "the", "quick", "brown", "fox", "jumps" };

IEnumerable<string> query = from word in words
                            orderby word.Length, word.Substring(0, 1) descending
                            select word;

foreach (string str in query)
    Console.WriteLine(str);

/* This code produces the following output:

    the
    fox
    quick
    jumps
    brown
*/
```

See also

- System.Linq
- Standard Query Operators Overview (C#)
- orderby clause
- How to: Order the Results of a Join Clause
- How to: Sort or Filter Text Data by Any Word or Field (LINQ) (C#)

Set Operations (C#)

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Set operations in LINQ refer to query operations that produce a result set that is based on the presence or absence of equivalent elements within the same or separate collections (or sets).

The standard query operator methods that perform set operations are listed in the following section.

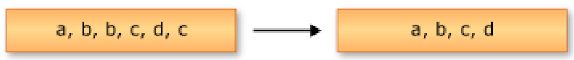
Methods

METHOD NAME	DESCRIPTION	C# QUERY EXPRESSION SYNTAX	MORE INFORMATION
Distinct	Removes duplicate values from a collection.	Not applicable.	Enumerable.Distinct Queryable.Distinct
Except	Returns the set difference, which means the elements of one collection that do not appear in a second collection.	Not applicable.	Enumerable.Except Queryable.Except
Intersect	Returns the set intersection, which means elements that appear in each of two collections.	Not applicable.	Enumerable.Intersect Queryable.Intersect
Union	Returns the set union, which means unique elements that appear in either of two collections.	Not applicable.	Enumerable.Union Queryable.Union

Comparison of Set Operations

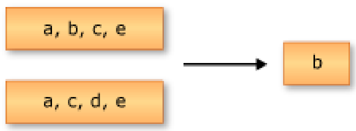
Distinct

The following illustration depicts the behavior of the Enumerable.Distinct method on a sequence of characters. The returned sequence contains the unique elements from the input sequence.



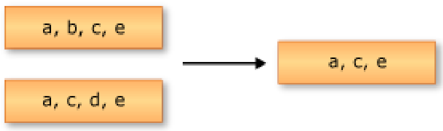
Except

The following illustration depicts the behavior of Enumerable.Except. The returned sequence contains only the elements from the first input sequence that are not in the second input sequence.



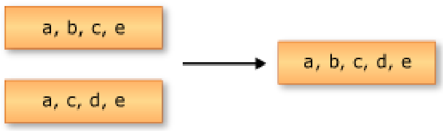
Intersect

The following illustration depicts the behavior of Enumerable.Intersect. The returned sequence contains the elements that are common to both of the input sequences.



Union

The following illustration depicts a union operation on two sequences of characters. The returned sequence contains the unique elements from both input sequences.



See also

- System.Linq
- Standard Query Operators Overview (C#)
- How to: Combine and Compare String Collections (LINQ) (C#)
- How to: Find the Set Difference Between Two Lists (LINQ) (C#)

Filtering Data (C#)

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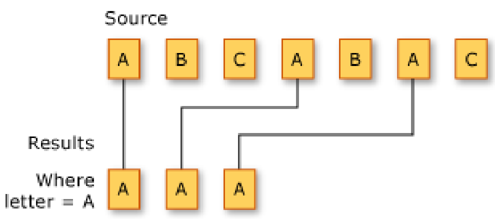
Filtering refers to the operation of restricting the result set to contain only those elements that satisfy a specified condition. It is also known as selection.

The following illustration shows the results of filtering a sequence of characters. The predicate for the filtering operation specifies that the character must be 'A'.



The standard query operator methods that perform selection are listed in the following section.

Methods

METHOD NAME	DESCRIPTION	C# QUERY EXPRESSION SYNTAX	MORE INFORMATION
OfType	Selects values, depending on their ability to be cast to a specified type.	Not applicable.	Enumerable.OfType Queryable.OfType
Where	Selects values that are based on a predicate function.	`where`	Enumerable.Where Queryable.Where

Query Expression Syntax Example

The following example uses the `where` clause to filter from an array those strings that have a specific length.

```
string[] words = { "the", "quick", "brown", "fox", "jumps" };

IEnumerable<string> query = from word in words
                            where word.Length == 3
                            select word;

foreach (string str in query)
    Console.WriteLine(str);

/* This code produces the following output:

    the
    fox
*/
```

See also

- System.Linq

- Standard Query Operators Overview (C#)
- where clause
- How to: Dynamically Specify Predicate Filters at Runtime
- How to: Query An Assembly's Metadata with Reflection (LINQ) (C#)
- How to: Query for Files with a Specified Attribute or Name (C#)
- How to: Sort or Filter Text Data by Any Word or Field (LINQ) (C#)

Quantifier Operations (C#)

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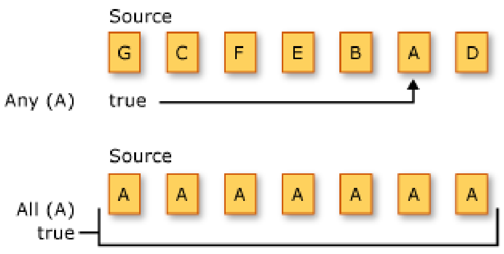
Quantifier operations return a Boolean value that indicates whether some or all of the elements in a sequence satisfy a condition.

The following illustration depicts two different quantifier operations on two different source sequences. The first operation asks if one or more of the elements are the character 'A', and the result is `true`. The second operation asks if all the elements are the character 'A', and the result is `true`.



The standard query operator methods that perform quantifier operations are listed in the following section.

Methods

METHOD NAME	DESCRIPTION	C# QUERY EXPRESSION SYNTAX	MORE INFORMATION
All	Determines whether all the elements in a sequence satisfy a condition.	Not applicable.	Enumerable.All Queryable.All
Any	Determines whether any elements in a sequence satisfy a condition.	Not applicable.	Enumerable.Any Queryable.Any
Contains	Determines whether a sequence contains a specified element.	Not applicable.	Enumerable.Contains Queryable.Contains

See also

- System.Linq
- Standard Query Operators Overview (C#)
- How to: Dynamically Specify Predicate Filters at Runtime
- How to: Query for Sentences that Contain a Specified Set of Words (LINQ) (C#)

Projection Operations (C#)

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Projection refers to the operation of transforming an object into a new form that often consists only of those properties that will be subsequently used. By using projection, you can construct a new type that is built from each object. You can project a property and perform a mathematical function on it. You can also project the original object without changing it.

The standard query operator methods that perform projection are listed in the following section.

Methods

METHOD NAME	DESCRIPTION	C# QUERY EXPRESSION SYNTAX	MORE INFORMATION
Select	Projects values that are based on a transform function.	`select`	Enumerable.Select Queryable.Select
SelectMany	Projects sequences of values that are based on a transform function and then flattens them into one sequence.	Use multiple `from` clauses	Enumerable.SelectMany Queryable.SelectMany

Query Expression Syntax Examples

Select

The following example uses the `select` clause to project the first letter from each string in a list of strings.

```
List<string> words = new List<string>() { "an", "apple", "a", "day" };

var query = from word in words
            select word.Substring(0, 1);

foreach (string s in query)
    Console.WriteLine(s);

/* This code produces the following output:

    a
    a
    a
    d
*/
```

SelectMany

The following example uses multiple `from` clauses to project each word from each string in a list of strings.

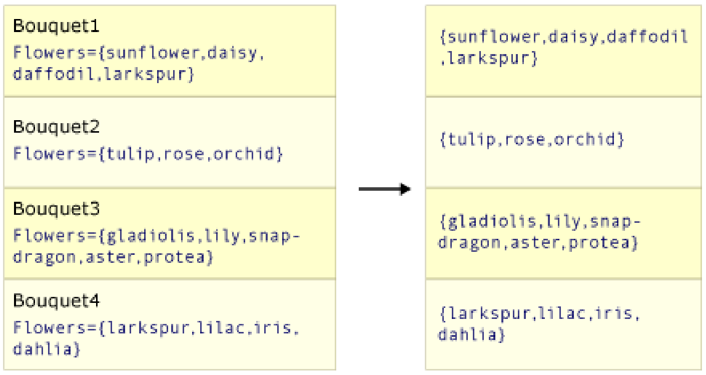
```
List<string> phrases = new List<string>() { "an apple a day", "the quick brown fox" };

var query = from phrase in phrases
            from word in phrase.Split(' ')
            select word;

foreach (string s in query)
    Console.WriteLine(s);

/* This code produces the following output:

    an
    apple
    a
    day
    the
    quick
    brown
    fox
*/
```

Select versus SelectMany

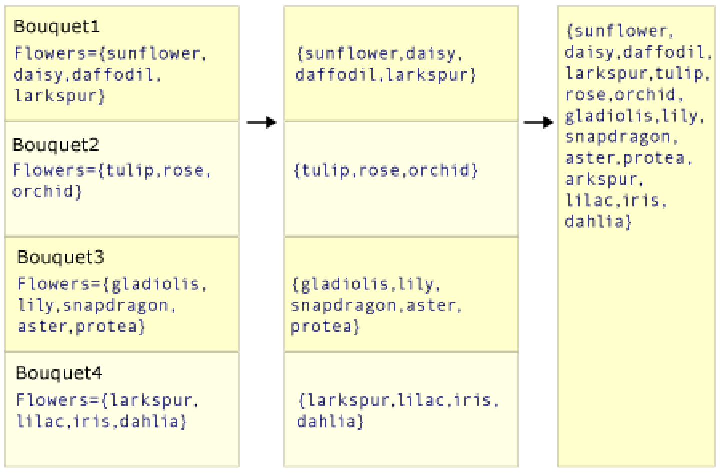
The work of both `Select()` and `SelectMany()` is to produce a result value (or values) from source values. `Select()` produces one result value for every source value. The overall result is therefore a collection that has the same number of elements as the source collection. In contrast, `SelectMany()` produces a single overall result that contains concatenated sub-collections from each source value. The transform function that is passed as an argument to `SelectMany()` must return an enumerable sequence of values for each source value. These enumerable sequences are then concatenated by `SelectMany()` to create one large sequence.

The following two illustrations show the conceptual difference between the actions of these two methods. In each case, assume that the selector (transform) function selects the array of flowers from each source value.

This illustration depicts how `Select()` returns a collection that has the same number of elements as the source collection.


Bouquet1
Flowers={sunflower,daisy,daffodil,larkspur}
Bouquet2
Flowers={tulip,rose,orchid}
Bouquet3
Flowers={gladiolis,lily,snap-dragon,aster,protea}
Bouquet4
Flowers={larkspur,lilac,iris,dahlia}
{sunflower,daisy,daffodil,larkspur}
{tulip,rose,orchid}
{gladiolis,lily,snap-dragon,aster,protea}
{larkspur,lilac,iris,dahlia}

This illustration depicts how `SelectMany()` concatenates the intermediate sequence of arrays into one final result value that contains each value from each intermediate array.


Bouquet1
Flowers={sunflower, daisy,daffodil, larkspur}
Bouquet2
Flowers={tulip,rose, orchid}
Bouquet3
Flowers={gladiolis, lily,snapdragon, aster,protea}
Bouquet4
Flowers={larkspur, lilac,iris,dahlia}
{sunflower,daisy, daffodil,larkspur}
{tulip,rose,orchid}
{gladiolis,lily, snapdragon,aster, protea}
{larkspur,lilac,iris, dahlia}
{sunflower, daisy,daffodil, larkspur,tulip, rose,orchid, gladiolis,lily, snapdragon, aster,protea, arkspur, lilac,iris, dahlia}

Code Example

The following example compares the behavior of `Select()` and `SelectMany()`. The code creates a "bouquet" of flowers by taking the first two items from each list of flower names in the source collection. In this example, the "single value" that the transform function Select<TSource,TResult>(IEnumerable<TSource>, Func<TSource,TResult>) uses is itself a collection of values. This requires the extra `foreach` loop in order to enumerate each string in each sub-sequence.

```
class Bouquet
{
    public List<string> Flowers { get; set; }
}

static void SelectVsSelectMany()
{
    List<Bouquet> bouquets = new List<Bouquet>() {
        new Bouquet { Flowers = new List<string> { "sunflower", "daisy", "daffodil", "larkspur" }},
        new Bouquet{ Flowers = new List<string> { "tulip", "rose", "orchid" }},
        new Bouquet{ Flowers = new List<string> { "gladiolis", "lily", "snapdragon", "aster", "protea" }},
        new Bouquet{ Flowers = new List<string> { "larkspur", "lilac", "iris", "dahlia" }}
    };

    // *********** Select ***********
    IEnumerable<List<string>> query1 = bouquets.Select(bq => bq.Flowers);

    // ********* SelectMany *********
    IEnumerable<string> query2 = bouquets.SelectMany(bq => bq.Flowers);

    Console.WriteLine("Results by using Select():");
    // Note the extra foreach loop here.
    foreach (IEnumerable<String> collection in query1)
        foreach (string item in collection)
            Console.WriteLine(item);

    Console.WriteLine("\nResults by using SelectMany():");
    foreach (string item in query2)
        Console.WriteLine(item);

    /* This code produces the following output:

       Results by using Select():
        sunflower
        daisy
        daffodil
        larkspur
        tulip
        rose
        orchid
        gladiolis
        lily
```

```
         aster
         protea
         larkspur
         lilac
         iris
         dahlia

        Results by using SelectMany():
         sunflower
         daisy
         daffodil
         larkspur
         tulip
         rose
         orchid
         gladiolis
         lily
         snapdragon
         aster
         protea
         larkspur
         lilac
         iris
         dahlia
    */

}
```

See also

- System.Linq
- Standard Query Operators Overview (C#)
- select clause
- How to: Populate Object Collections from Multiple Sources (LINQ) (C#)
- How to: Split a File Into Many Files by Using Groups (LINQ) (C#)

Partitioning Data (C#)

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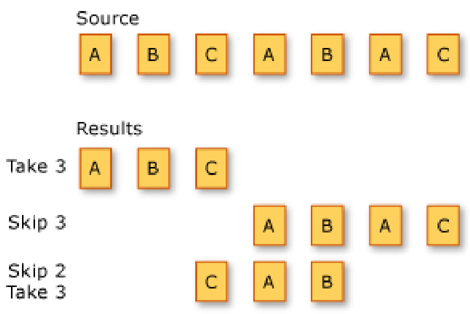
Partitioning in LINQ refers to the operation of dividing an input sequence into two sections, without rearranging the elements, and then returning one of the sections.

The following illustration shows the results of three different partitioning operations on a sequence of characters. The first operation returns the first three elements in the sequence. The second operation skips the first three elements and returns the remaining elements. The third operation skips the first two elements in the sequence and returns the next three elements.



The standard query operator methods that partition sequences are listed in the following section.

Operators

OPERATOR NAME	DESCRIPTION	C# QUERY EXPRESSION SYNTAX	MORE INFORMATION
Skip	Skips elements up to a specified position in a sequence.	Not applicable.	Enumerable.Skip Queryable.Skip
SkipWhile	Skips elements based on a predicate function until an element does not satisfy the condition.	Not applicable.	Enumerable.SkipWhile Queryable.SkipWhile
Take	Takes elements up to a specified position in a sequence.	Not applicable.	Enumerable.Take Queryable.Take
TakeWhile	Takes elements based on a predicate function until an element does not satisfy the condition.	Not applicable.	Enumerable.TakeWhile Queryable.TakeWhile

See also

- System.Linq
- Standard Query Operators Overview (C#)

Join Operations (C#)

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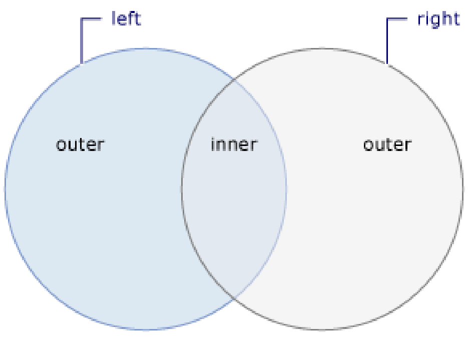
A *join* of two data sources is the association of objects in one data source with objects that share a common attribute in another data source.

Joining is an important operation in queries that target data sources whose relationships to each other cannot be followed directly. In object-oriented programming, this could mean a correlation between objects that is not modeled, such as the backwards direction of a one-way relationship. An example of a one-way relationship is a Customer class that has a property of type City, but the City class does not have a property that is a collection of Customer objects. If you have a list of City objects and you want to find all the customers in each city, you could use a join operation to find them.

The join methods provided in the LINQ framework are Join and GroupJoin. These methods perform equijoins, or joins that match two data sources based on equality of their keys. (For comparison, Transact-SQL supports join operators other than 'equals', for example the 'less than' operator.) In relational database terms, Join implements an inner join, a type of join in which only those objects that have a match in the other data set are returned. The GroupJoin method has no direct equivalent in relational database terms, but it implements a superset of inner joins and left outer joins. A left outer join is a join that returns each element of the first (left) data source, even if it has no correlated elements in the other data source.

The following illustration shows a conceptual view of two sets and the elements within those sets that are included in either an inner join or a left outer join.



Methods

METHOD NAME	DESCRIPTION	C# QUERY EXPRESSION SYNTAX	MORE INFORMATION
Join	Joins two sequences based on key selector functions and extracts pairs of values.	`join … in … on … equals …`	Enumerable.Join Queryable.Join
GroupJoin	Joins two sequences based on key selector functions and groups the resulting matches for each element.	`join … in … on … equals … into …`	Enumerable.GroupJoin Queryable.GroupJoin

See also

- System.Linq
- Standard Query Operators Overview (C#)

- Anonymous Types
- Formulate Joins and Cross-Product Queries
- join clause
- How to: Join by Using Composite Keys
- How to: Join Content from Dissimilar Files (LINQ) (C#)
- How to: Order the Results of a Join Clause
- How to: Perform Custom Join Operations
- How to: Perform Grouped Joins
- How to: Perform Inner Joins
- How to: Perform Left Outer Joins
- How to: Populate Object Collections from Multiple Sources (LINQ) (C#)

Grouping Data (C#)

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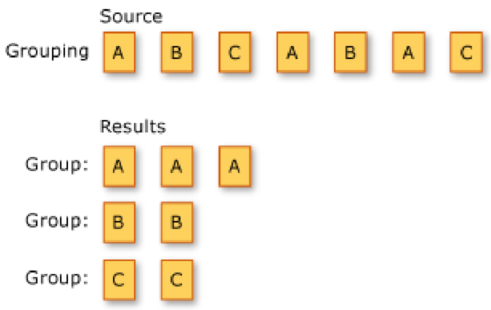
Grouping refers to the operation of putting data into groups so that the elements in each group share a common attribute.

The following illustration shows the results of grouping a sequence of characters. The key for each group is the character.



The standard query operator methods that group data elements are listed in the following section.

Methods

METHOD NAME	DESCRIPTION	C# QUERY EXPRESSION SYNTAX	MORE INFORMATION
GroupBy	Groups elements that share a common attribute. Each group is represented by an IGrouping<TKey,TElement> object.	`group … by` -or- `group … by … into …`	Enumerable.GroupBy Queryable.GroupBy
ToLookup	Inserts elements into a Lookup<TKey,TElement> (a one-to-many dictionary) based on a key selector function.	Not applicable.	Enumerable.ToLookup

Query Expression Syntax Example

The following code example uses the `group by` clause to group integers in a list according to whether they are even or odd.

```
List<int> numbers = new List<int>() { 35, 44, 200, 84, 3987, 4, 199, 329, 446, 208 };

IEnumerable<IGrouping<int, int>> query = from number in numbers
                                         group number by number % 2;

foreach (var group in query)
{
    Console.WriteLine(group.Key == 0 ? "\nEven numbers:" : "\nOdd numbers:");
    foreach (int i in group)
        Console.WriteLine(i);
}

/* This code produces the following output:

    Odd numbers:
    35
    3987
    199
    329

    Even numbers:
    44
    200
    84
    4
    446
    208
*/
```

See also

- System.Linq
- Standard Query Operators Overview (C#)
- group clause
- How to: Create a Nested Group
- How to: Group Files by Extension (LINQ) (C#)
- How to: Group Query Results
- How to: Perform a Subquery on a Grouping Operation
- How to: Split a File Into Many Files by Using Groups (LINQ) (C#)

Generation Operations (C#)

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Generation refers to creating a new sequence of values.

The standard query operator methods that perform generation are listed in the following section.

Methods

METHOD NAME	DESCRIPTION	C# QUERY EXPRESSION SYNTAX	MORE INFORMATION
DefaultIfEmpty	Replaces an empty collection with a default valued singleton collection.	Not applicable.	Enumerable.DefaultIfEmpty Queryable.DefaultIfEmpty
Empty	Returns an empty collection.	Not applicable.	Enumerable.Empty
Range	Generates a collection that contains a sequence of numbers.	Not applicable.	Enumerable.Range
Repeat	Generates a collection that contains one repeated value.	Not applicable.	Enumerable.Repeat

See also

- System.Linq
- Standard Query Operators Overview (C#)

Equality Operations (C#)

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Two sequences whose corresponding elements are equal and which have the same number of elements are considered equal.

Methods

METHOD NAME	DESCRIPTION	C# QUERY EXPRESSION SYNTAX	MORE INFORMATION
SequenceEqual	Determines whether two sequences are equal by comparing elements in a pair-wise manner.	Not applicable.	Enumerable.SequenceEqual Queryable.SequenceEqual

See also

- System.Linq
- Standard Query Operators Overview (C#)
- How to: Compare the Contents of Two Folders (LINQ) (C#)

Element Operations (C#)

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Element operations return a single, specific element from a sequence.

The standard query operator methods that perform element operations are listed in the following section.

Methods

METHOD NAME	DESCRIPTION	C# QUERY EXPRESSION SYNTAX	MORE INFORMATION
ElementAt	Returns the element at a specified index in a collection.	Not applicable.	Enumerable.ElementAt Queryable.ElementAt
ElementAtOrDefault	Returns the element at a specified index in a collection or a default value if the index is out of range.	Not applicable.	Enumerable.ElementAtOrDefault Queryable.ElementAtOrDefault
First	Returns the first element of a collection, or the first element that satisfies a condition.	Not applicable.	Enumerable.First Queryable.First
FirstOrDefault	Returns the first element of a collection, or the first element that satisfies a condition. Returns a default value if no such element exists.	Not applicable.	Enumerable.FirstOrDefault Queryable.FirstOrDefault Queryable.FirstOrDefault<TSource>(IQueryable<TSource>)
Last	Returns the last element of a collection, or the last element that satisfies a condition.	Not applicable.	Enumerable.Last Queryable.Last
LastOrDefault	Returns the last element of a collection, or the last element that satisfies a condition. Returns a default value if no such element exists.	Not applicable.	Enumerable.LastOrDefault Queryable.LastOrDefault
Single	Returns the only element of a collection or the only element that satisfies a condition. Throws an InvalidOperationException if there is no element or more than one element to return.	Not applicable.	Enumerable.Single Queryable.Single

METHOD NAME	DESCRIPTION	C# QUERY EXPRESSION SYNTAX	MORE INFORMATION
SingleOrDefault	Returns the only element of a collection or the only element that satisfies a condition. Returns a default value if there is no element to return. Throws an InvalidOperationException if there is more than one element to return.	Not applicable.	Enumerable.SingleOrDefault Queryable.SingleOrDefault

See also

- System.Linq
- Standard Query Operators Overview (C#)
- How to: Query for the Largest File or Files in a Directory Tree (LINQ) (C#)

Converting Data Types (C#)

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Conversion methods change the type of input objects.

Conversion operations in LINQ queries are useful in a variety of applications. Following are some examples:

- The Enumerable.AsEnumerable method can be used to hide a type's custom implementation of a standard query operator.
- The Enumerable.OfType method can be used to enable non-parameterized collections for LINQ querying.
- The Enumerable.ToArray, Enumerable.ToDictionary, Enumerable.ToList, and Enumerable.ToLookup methods can be used to force immediate query execution instead of deferring it until the query is enumerated.

Methods

The following table lists the standard query operator methods that perform data-type conversions.

The conversion methods in this table whose names start with "As" change the static type of the source collection but do not enumerate it. The methods whose names start with "To" enumerate the source collection and put the items into the corresponding collection type.

METHOD NAME	DESCRIPTION	C# QUERY EXPRESSION SYNTAX	MORE INFORMATION
AsEnumerable	Returns the input typed as IEnumerable<T>.	Not applicable.	Enumerable.AsEnumerable
AsQueryable	Converts a (generic) IEnumerable to a (generic) IQueryable.	Not applicable.	Queryable.AsQueryable
Cast	Casts the elements of a collection to a specified type.	Use an explicitly typed range variable. For example: `from string str in words`	Enumerable.Cast Queryable.Cast
OfType	Filters values, depending on their ability to be cast to a specified type.	Not applicable.	Enumerable.OfType Queryable.OfType
ToArray	Converts a collection to an array. This method forces query execution.	Not applicable.	Enumerable.ToArray
ToDictionary	Puts elements into a Dictionary<TKey,TValue> based on a key selector function. This method forces query execution.	Not applicable.	Enumerable.ToDictionary

METHOD NAME	DESCRIPTION	C# QUERY EXPRESSION SYNTAX	MORE INFORMATION
ToList	Converts a collection to a List<T>. This method forces query execution.	Not applicable.	Enumerable.ToList
ToLookup	Puts elements into a Lookup<TKey,TElement> (a one-to-many dictionary) based on a key selector function. This method forces query execution.	Not applicable.	Enumerable.ToLookup

Query Expression Syntax Example

The following code example uses an explicitly-typed range variable to cast a type to a subtype before accessing a member that is available only on the subtype.

```
class Plant
{
    public string Name { get; set; }
}

class CarnivorousPlant : Plant
{
    public string TrapType { get; set; }
}

static void Cast()
{
    Plant[] plants = new Plant[] {
        new CarnivorousPlant { Name = "Venus Fly Trap", TrapType = "Snap Trap" },
        new CarnivorousPlant { Name = "Pitcher Plant", TrapType = "Pitfall Trap" },
        new CarnivorousPlant { Name = "Sundew", TrapType = "Flypaper Trap" },
        new CarnivorousPlant { Name = "Waterwheel Plant", TrapType = "Snap Trap" }
    };

    var query = from CarnivorousPlant cPlant in plants
                where cPlant.TrapType == "Snap Trap"
                select cPlant;

    foreach (Plant plant in query)
        Console.WriteLine(plant.Name);

    /* This code produces the following output:

        Venus Fly Trap
        Waterwheel Plant
    */
}
```

See also

- System.Linq
- Standard Query Operators Overview (C#)
- from clause
- LINQ Query Expressions
- How to: Query an ArrayList with LINQ (C#)

Concatenation Operations (C#)

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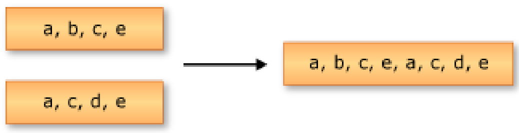
Concatenation refers to the operation of appending one sequence to another.

The following illustration depicts a concatenation operation on two sequences of characters.



The standard query operator methods that perform concatenation are listed in the following section.

Methods

METHOD NAME	DESCRIPTION	C# QUERY EXPRESSION SYNTAX	MORE INFORMATION
Concat	Concatenates two sequences to form one sequence.	Not applicable.	Enumerable.Concat Queryable.Concat

See also

- System.Linq
- Standard Query Operators Overview (C#)
- How to: Combine and Compare String Collections (LINQ) (C#)

Aggregation Operations (C#)

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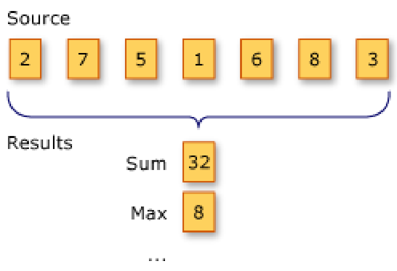
An aggregation operation computes a single value from a collection of values. An example of an aggregation operation is calculating the average daily temperature from a month's worth of daily temperature values.

The following illustration shows the results of two different aggregation operations on a sequence of numbers. The first operation sums the numbers. The second operation returns the maximum value in the sequence.



The standard query operator methods that perform aggregation operations are listed in the following section.

Methods

METHOD NAME	DESCRIPTION	C# QUERY EXPRESSION SYNTAX	MORE INFORMATION
Aggregate	Performs a custom aggregation operation on the values of a collection.	Not applicable.	Enumerable.Aggregate Queryable.Aggregate
Average	Calculates the average value of a collection of values.	Not applicable.	Enumerable.Average Queryable.Average
Count	Counts the elements in a collection, optionally only those elements that satisfy a predicate function.	Not applicable.	Enumerable.Count Queryable.Count
LongCount	Counts the elements in a large collection, optionally only those elements that satisfy a predicate function.	Not applicable.	Enumerable.LongCount Queryable.LongCount
Max	Determines the maximum value in a collection.	Not applicable.	Enumerable.Max Queryable.Max
Min	Determines the minimum value in a collection.	Not applicable.	Enumerable.Min Queryable.Min
Sum	Calculates the sum of the values in a collection.	Not applicable.	Enumerable.Sum Queryable.Sum

See also

- System.Linq
- Standard Query Operators Overview (C#)
- How to: Compute Column Values in a CSV Text File (LINQ) (C#)
- How to: Query for the Largest File or Files in a Directory Tree (LINQ) (C#)
- How to: Query for the Total Number of Bytes in a Set of Folders (LINQ) (C#)

LINQ to Objects (C#)

9/5/2018 • 2 minutes to read • Edit Online

The term "LINQ to Objects" refers to the use of LINQ queries with any IEnumerable or IEnumerable<T> collection directly, without the use of an intermediate LINQ provider or API such as LINQ to SQL or LINQ to XML. You can use LINQ to query any enumerable collections such as List<T>, Array, or Dictionary<TKey,TValue>. The collection may be user-defined or may be returned by a .NET Framework API.

In a basic sense, LINQ to Objects represents a new approach to collections. In the old way, you had to write complex `foreach` loops that specified how to retrieve data from a collection. In the LINQ approach, you write declarative code that describes what you want to retrieve.

In addition, LINQ queries offer three main advantages over traditional `foreach` loops:

1. They are more concise and readable, especially when filtering multiple conditions.
2. They provide powerful filtering, ordering, and grouping capabilities with a minimum of application code.
3. They can be ported to other data sources with little or no modification.

In general, the more complex the operation you want to perform on the data, the more benefit you will realize by using LINQ instead of traditional iteration techniques.

The purpose of this section is to demonstrate the LINQ approach with some select examples. It is not intended to be exhaustive.

In This Section

LINQ and Strings (C#)
Explains how LINQ can be used to query and transform strings and collections of strings. Also includes links to topics that demonstrate these principles.

LINQ and Reflection (C#)
Links to a sample that demonstrates how LINQ uses reflection.

LINQ and File Directories (C#)
Explains how LINQ can be used to interact with file systems. Also includes links to topics that demonstrate these concepts.

How to: Query an ArrayList with LINQ (C#)
Demonstrates how to query an ArrayList in C#.

How to: Add Custom Methods for LINQ Queries (C#)
Explains how to extend the set of methods that you can use for LINQ queries by adding extension methods to the IEnumerable<T> interface.

Language-Integrated Query (LINQ) (C#)
Provides links to topics that explain LINQ and provide examples of code that perform queries.

LINQ and strings (C#)

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LINQ can be used to query and transform strings and collections of strings. It can be especially useful with semi-structured data in text files. LINQ queries can be combined with traditional string functions and regular expressions. For example, you can use the String.Split or Regex.Split method to create an array of strings that you can then query or modify by using LINQ. You can use the Regex.IsMatch method in the `where` clause of a LINQ query. And you can use LINQ to query or modify the MatchCollection results returned by a regular expression.

You can also use the techniques described in this section to transform semi-structured text data to XML. For more information, see How to: Generate XML from CSV Files.

The examples in this section fall into two categories:

Querying a block of text

You can query, analyze, and modify text blocks by splitting them into a queryable array of smaller strings by using the String.Split method or the Regex.Split method. You can split the source text into words, sentences, paragraphs, pages, or any other criteria, and then perform additional splits if they are required in your query.

- How to: Count Occurrences of a Word in a String (LINQ) (C#)
  Shows how to use LINQ for simple querying over text.
- How to: Query for Sentences that Contain a Specified Set of Words (LINQ) (C#)

  Shows how to split text files on arbitrary boundaries and how to perform queries against each part.
- How to: Query for Characters in a String (LINQ) (C#)

  Demonstrates that a string is a queryable type.
- How to: Combine LINQ Queries with Regular Expressions (C#)

  Shows how to use regular expressions in LINQ queries for complex pattern matching on filtered query results.

Querying semi-structured data in text format

Many different types of text files consist of a series of lines, often with similar formatting, such as tab- or comma-delimited files or fixed-length lines. After you read such a text file into memory, you can use LINQ to query and/or modify the lines. LINQ queries also simplify the task of combining data from multiple sources.

- How to: Find the Set Difference Between Two Lists (LINQ) (C#)

  Shows how to find all the strings that are present in one list but not the other.
- How to: Sort or Filter Text Data by Any Word or Field (LINQ) (C#)

  Shows how to sort text lines based on any word or field.
- How to: Reorder the Fields of a Delimited File (LINQ) (C#)

  Shows how to reorder fields in a line in a .csv file.
- How to: Combine and Compare String Collections (LINQ) (C#)

Shows how to combine string lists in various ways.

- How to: Populate Object Collections from Multiple Sources (LINQ) (C#)

  Shows how to create object collections by using multiple text files as data sources.

- How to: Join Content from Dissimilar Files (LINQ) (C#)

  Shows how to combine strings in two lists into a single string by using a matching key.

- How to: Split a File Into Many Files by Using Groups (LINQ) (C#)

  Shows how to create new files by using a single file as a data source.

- How to: Compute Column Values in a CSV Text File (LINQ) (C#)

  Shows how to perform mathematical computations on text data in .csv files.

See also

- Language-Integrated Query (LINQ) (C#)
- How to: Generate XML from CSV Files

How to: Count Occurrences of a Word in a String (LINQ) (C#)

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This example shows how to use a LINQ query to count the occurrences of a specified word in a string. Note that to perform the count, first the Split method is called to create an array of words. There is a performance cost to the Split method. If the only operation on the string is to count the words, you should consider using the Matches or IndexOf methods instead. However, if performance is not a critical issue, or you have already split the sentence in order to perform other types of queries over it, then it makes sense to use LINQ to count the words or phrases as well.

Example

```
class CountWords
{
    static void Main()
    {
        string text = @"Historically, the world of data and the world of objects" +
          @" have not been well integrated. Programmers work in C# or Visual Basic" +
          @" and also in SQL or XQuery. On the one side are concepts such as classes," +
          @" objects, fields, inheritance, and .NET Framework APIs. On the other side" +
          @" are tables, columns, rows, nodes, and separate languages for dealing with" +
          @" them. Data types often require translation between the two worlds; there are" +
          @" different standard functions. Because the object world has no notion of query, a" +
          @" query can only be represented as a string without compile-time type checking or" +
          @" IntelliSense support in the IDE. Transferring data from SQL tables or XML trees to" +
          @" objects in memory is often tedious and error-prone.";

        string searchTerm = "data";

        //Convert the string into an array of words
        string[] source = text.Split(new char[] { '.', '?', '!', ' ', ';', ':', ',' },
StringSplitOptions.RemoveEmptyEntries);

        // Create the query.  Use ToLowerInvariant to match "data" and "Data"
        var matchQuery = from word in source
                         where word.ToLowerInvariant() == searchTerm.ToLowerInvariant()
                         select word;

        // Count the matches, which executes the query.
        int wordCount = matchQuery.Count();
        Console.WriteLine("{0} occurrences(s) of the search term \"{1}\" were found.", wordCount, searchTerm);

        // Keep console window open in debug mode
        Console.WriteLine("Press any key to exit");
        Console.ReadKey();
    }
}
/* Output:
   3 occurrences(s) of the search term "data" were found.
*/
```

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher, with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ and Strings (C#)

How to: Query for Sentences that Contain a Specified Set of Words (LINQ) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example shows how to find sentences in a text file that contain matches for each of a specified set of words. Although the array of search terms is hard-coded in this example, it could also be populated dynamically at runtime. In this example, the query returns the sentences that contain the words "Historically," "data," and "integrated."

Example

```
class FindSentences
{
    static void Main()
    {
        string text = @"Historically, the world of data and the world of objects " +
        @"have not been well integrated. Programmers work in C# or Visual Basic " +
        @"and also in SQL or XQuery. On the one side are concepts such as classes, " +
        @"objects, fields, inheritance, and .NET Framework APIs. On the other side " +
        @"are tables, columns, rows, nodes, and separate languages for dealing with " +
        @"them. Data types often require translation between the two worlds; there are " +
        @"different standard functions. Because the object world has no notion of query, a " +
        @"query can only be represented as a string without compile-time type checking or " +
        @"IntelliSense support in the IDE. Transferring data from SQL tables or XML trees to " +
        @"objects in memory is often tedious and error-prone.";

        // Split the text block into an array of sentences.
        string[] sentences = text.Split(new char[] { '.', '?', '!' });

        // Define the search terms. This list could also be dynamically populated at runtime.
        string[] wordsToMatch = { "Historically", "data", "integrated" };

        // Find sentences that contain all the terms in the wordsToMatch array.
        // Note that the number of terms to match is not specified at compile time.
        var sentenceQuery = from sentence in sentences
                            let w = sentence.Split(new char[] { '.', '?', '!', ' ', ';', ':', ',' },
                                                    StringSplitOptions.RemoveEmptyEntries)
                            where w.Distinct().Intersect(wordsToMatch).Count() == wordsToMatch.Count()
                            select sentence;

        // Execute the query. Note that you can explicitly type
        // the iteration variable here even though sentenceQuery
        // was implicitly typed.
        foreach (string str in sentenceQuery)
        {
            Console.WriteLine(str);
        }

        // Keep the console window open in debug mode.
        Console.WriteLine("Press any key to exit");
        Console.ReadKey();
    }
}
/* Output:
Historically, the world of data and the world of objects have not been well integrated
*/
```

The query works by first splitting the text into sentences, and then splitting the sentences into an array of strings that hold each word. For each of these arrays, the Distinct method removes all duplicate words, and then the query performs an Intersect operation on the word array and the `wordsToMatch` array. If the count of the intersection is the same as the count of the `wordsToMatch` array, all words were found in the words and the original sentence is returned.

In the call to Split, the punctuation marks are used as separators in order to remove them from the string. If you did not do this, for example you could have a string "Historically," that would not match "Historically" in the `wordsToMatch` array. You may have to use additional separators, depending on the types of punctuation found in the source text.

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher, with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ and Strings (C#)

How to: Query for Characters in a String (LINQ) (C#)

1/23/2019 • 2 minutes to read • Edit Online

Because the String class implements the generic IEnumerable<T> interface, any string can be queried as a sequence of characters. However, this is not a common use of LINQ. For complex pattern matching operations, use the Regex class.

Example

The following example queries a string to determine the number of numeric digits it contains. Note that the query is "reused" after it is executed the first time. This is possible because the query itself does not store any actual results.

```
class QueryAString
{
    static void Main()
    {
        string aString = "ABCDE99F-J74-12-89A";

        // Select only those characters that are numbers
        IEnumerable<char> stringQuery =
          from ch in aString
          where Char.IsDigit(ch)
          select ch;

        // Execute the query
        foreach (char c in stringQuery)
            Console.Write(c + " ");

        // Call the Count method on the existing query.
        int count = stringQuery.Count();
        Console.WriteLine("Count = {0}", count);

        // Select all characters before the first '-'
        IEnumerable<char> stringQuery2 = aString.TakeWhile(c => c != '-');

        // Execute the second query
        foreach (char c in stringQuery2)
            Console.Write(c);

        Console.WriteLine(System.Environment.NewLine + "Press any key to exit");
        Console.ReadKey();
    }
}
/* Output:
  Output: 9 9 7 4 1 2 8 9
  Count = 8
  ABCDE99F
*/
```

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher, with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ and Strings (C#)
- How to: Combine LINQ Queries with Regular Expressions (C#)

How to: Combine LINQ Queries with Regular Expressions (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example shows how to use the Regex class to create a regular expression for more complex matching in text strings. The LINQ query makes it easy to filter on exactly the files that you want to search with the regular expression, and to shape the results.

Example

```
class QueryWithRegEx
{
    public static void Main()
    {
        // Modify this path as necessary so that it accesses your version of Visual Studio.
        string startFolder = @"C:\Program Files (x86)\Microsoft Visual Studio 14.0\";
        // One of the following paths may be more appropriate on your computer.
        //string startFolder = @"C:\Program Files (x86)\Microsoft Visual Studio\2017\";

        // Take a snapshot of the file system.
        IEnumerable<System.IO.FileInfo> fileList = GetFiles(startFolder);

        // Create the regular expression to find all things "Visual".
        System.Text.RegularExpressions.Regex searchTerm =
            new System.Text.RegularExpressions.Regex(@"Visual (Basic|C#|C\+\+|Studio)");

        // Search the contents of each .htm file.
        // Remove the where clause to find even more matchedValues!
        // This query produces a list of files where a match
        // was found, and a list of the matchedValues in that file.
        // Note: Explicit typing of "Match" in select clause.
        // This is required because MatchCollection is not a
        // generic IEnumerable collection.
        var queryMatchingFiles =
            from file in fileList
            where file.Extension == ".htm"
            let fileText = System.IO.File.ReadAllText(file.FullName)
            let matches = searchTerm.Matches(fileText)
            where matches.Count > 0
            select new
            {
                name = file.FullName,
                matchedValues = from System.Text.RegularExpressions.Match match in matches
                                select match.Value
            };

        // Execute the query.
        Console.WriteLine("The term \"{0}\" was found in:", searchTerm.ToString());

        foreach (var v in queryMatchingFiles)
        {
            // Trim the path a bit, then write
            // the file name in which a match was found.
            string s = v.name.Substring(startFolder.Length - 1);
            Console.WriteLine(s);

            // For this file, write out all the matching strings
            foreach (var v2 in v.matchedValues)
            {
                Console.WriteLine("  " + v2);
            }
        }

        // Keep the console window open in debug mode
        Console.WriteLine("Press any key to exit");
        Console.ReadKey();
    }

    // This method assumes that the application has discovery
    // permissions for all folders under the specified path.
    static IEnumerable<System.IO.FileInfo> GetFiles(string path)
    {
        if (!System.IO.Directory.Exists(path))
            throw new System.IO.DirectoryNotFoundException();

        string[] fileNames = null;
        List<System.IO.FileInfo> files = new List<System.IO.FileInfo>();

        fileNames = System.IO.Directory.GetFiles(path, "*.*", System.IO.SearchOption.AllDirectories);
        foreach (string name in fileNames)
        {
            files.Add(new System.IO.FileInfo(name));
        }
        return files;
    }
}
```

Note that you can also query the MatchCollection object that is returned by a `RegEx` search. In this example only the value of each match is produced in the results. However, it is also possible to use LINQ to perform all kinds of filtering, sorting, and grouping on that collection. Because MatchCollection is a non-generic IEnumerable collection, you have to explicitly state the type of the range variable in the query.

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher, with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ and Strings (C#)
- LINQ and File Directories (C#)

How to: Find the Set Difference Between Two Lists (LINQ) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example shows how to use LINQ to compare two lists of strings and output those lines that are in names1.txt but not in names2.txt.

To create the data files

1. Copy names1.txt and names2.txt to your solution folder as shown in How to: Combine and Compare String Collections (LINQ) (C#).

Example

```
class CompareLists
{
    static void Main()
    {
        // Create the IEnumerable data sources.
        string[] names1 = System.IO.File.ReadAllLines(@"../../../names1.txt");
        string[] names2 = System.IO.File.ReadAllLines(@"../../../names2.txt");

        // Create the query. Note that method syntax must be used here.
        IEnumerable<string> differenceQuery =
          names1.Except(names2);

        // Execute the query.
        Console.WriteLine("The following lines are in names1.txt but not names2.txt");
        foreach (string s in differenceQuery)
            Console.WriteLine(s);

        // Keep the console window open in debug mode.
        Console.WriteLine("Press any key to exit");
        Console.ReadKey();
    }
}
/* Output:
     The following lines are in names1.txt but not names2.txt
    Potra, Cristina
    Noriega, Fabricio
    Aw, Kam Foo
    Toyoshima, Tim
    Guy, Wey Yuan
    Garcia, Debra
     */
```

Some types of query operations in C#, such as Except, Distinct, Union, and Concat, can only be expressed in method-based syntax.

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher, with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ and Strings (C#)

How to: Sort or Filter Text Data by Any Word or Field (LINQ) (C#)

1/23/2019 • 2 minutes to read • Edit Online

The following example shows how to sort lines of structured text, such as comma-separated values, by any field in the line. The field may be dynamically specified at runtime. Assume that the fields in scores.csv represent a student's ID number, followed by a series of four test scores.

To create a file that contains data

1. Copy the scores.csv data from the topic How to: Join Content from Dissimilar Files (LINQ) (C#) and save it to your solution folder.

Example

```
public class SortLines
{
    static void Main()
    {
        // Create an IEnumerable data source
        string[] scores = System.IO.File.ReadAllLines(@"../../../scores.csv");

        // Change this to any value from 0 to 4.
        int sortField = 1;

        Console.WriteLine("Sorted highest to lowest by field [{0}]:", sortField);

        // Demonstrates how to return query from a method.
        // The query is executed here.
        foreach (string str in RunQuery(scores, sortField))
        {
            Console.WriteLine(str);
        }

        // Keep the console window open in debug mode.
        Console.WriteLine("Press any key to exit");
        Console.ReadKey();
    }

    // Returns the query variable, not query results!
    static IEnumerable<string> RunQuery(IEnumerable<string> source, int num)
    {
        // Split the string and sort on field[num]
        var scoreQuery = from line in source
                         let fields = line.Split(',')
                         orderby fields[num] descending
                         select line;

        return scoreQuery;
    }
}
/* Output (if sortField == 1):
   Sorted highest to lowest by field [1]:
    116, 99, 86, 90, 94
    120, 99, 82, 81, 79
    111, 97, 92, 81, 60
    114, 97, 89, 85, 82
    121, 96, 85, 91, 60
    122, 94, 92, 91, 91
    117, 93, 92, 80, 87
    118, 92, 90, 83, 78
    113, 88, 94, 65, 91
    112, 75, 84, 91, 39
    119, 68, 79, 88, 92
    115, 35, 72, 91, 70
 */
```

This example also demonstrates how to return a query variable from a method.

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher, with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ and Strings (C#)

How to: Reorder the Fields of a Delimited File (LINQ) (C#)

1/23/2019 • 2 minutes to read • Edit Online

A comma-separated value (CSV) file is a text file that is often used to store spreadsheet data or other tabular data that is represented by rows and columns. By using the Split method to separate the fields, it is very easy to query and manipulate CSV files by using LINQ. In fact, the same technique can be used to reorder the parts of any structured line of text; it is not limited to CSV files.

In the following example, assume that the three columns represent students' "last name," "first name", and "ID." The fields are in alphabetical order based on the students' last names. The query produces a new sequence in which the ID column appears first, followed by a second column that combines the student's first name and last name. The lines are reordered according to the ID field. The results are saved into a new file and the original data is not modified.

To create the data file

1. Copy the following lines into a plain text file that is named spreadsheet1.csv. Save the file in your project folder.

```
Adams,Terry,120
Fakhouri,Fadi,116
Feng,Hanying,117
Garcia,Cesar,114
Garcia,Debra,115
Garcia,Hugo,118
Mortensen,Sven,113
O'Donnell,Claire,112
Omelchenko,Svetlana,111
Tucker,Lance,119
Tucker,Michael,122
Zabokritski,Eugene,121
```

Example

```
class CSVFiles
{
    static void Main(string[] args)
    {
        // Create the IEnumerable data source
        string[] lines = System.IO.File.ReadAllLines(@"../../../spreadsheet1.csv");

        // Create the query. Put field 2 first, then
        // reverse and combine fields 0 and 1 from the old field
        IEnumerable<string> query =
            from line in lines
            let x = line.Split(',')
            orderby x[2]
            select x[2] + ", " + (x[1] + " " + x[0]);

        // Execute the query and write out the new file. Note that WriteAllLines
        // takes a string[], so ToArray is called on the query.
        System.IO.File.WriteAllLines(@"../../../spreadsheet2.csv", query.ToArray());

        Console.WriteLine("Spreadsheet2.csv written to disk. Press any key to exit");
        Console.ReadKey();
    }
}
/* Output to spreadsheet2.csv:
111, Svetlana Omelchenko
112, Claire O'Donnell
113, Sven Mortensen
114, Cesar Garcia
115, Debra Garcia
116, Fadi Fakhouri
117, Hanying Feng
118, Hugo Garcia
119, Lance Tucker
120, Terry Adams
121, Eugene Zabokritski
122, Michael Tucker
 */
```

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher, with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ and Strings (C#)
- LINQ and File Directories (C#)
- How to: Generate XML from CSV Files (C#)

How to: Combine and Compare String Collections (LINQ) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example shows how to merge files that contain lines of text and then sort the results. Specifically, it shows how to perform a simple concatenation, a union, and an intersection on the two sets of text lines.

To set up the project and the text files

1. Copy these names into a text file that is named names1.txt and save it in your project folder:

```
Bankov, Peter
Holm, Michael
Garcia, Hugo
Potra, Cristina
Noriega, Fabricio
Aw, Kam Foo
Beebe, Ann
Toyoshima, Tim
Guy, Wey Yuan
Garcia, Debra
```

2. Copy these names into a text file that is named names2.txt and save it in your project folder. Note that the two files have some names in common.

```
Liu, Jinghao
Bankov, Peter
Holm, Michael
Garcia, Hugo
Beebe, Ann
Gilchrist, Beth
Myrcha, Jacek
Giakoumakis, Leo
McLin, Nkenge
El Yassir, Mehdi
```

Example

```
class MergeStrings
    {
        static void Main(string[] args)
        {
            //Put text files in your solution folder
            string[] fileA = System.IO.File.ReadAllLines(@"../../../names1.txt");
            string[] fileB = System.IO.File.ReadAllLines(@"../../../names2.txt");

            //Simple concatenation and sort. Duplicates are preserved.
            IEnumerable<string> concatQuery =
                fileA.Concat(fileB).OrderBy(s => s);

            // Pass the query variable to another function for execution.
            OutputQueryResults(concatQuery, "Simple concatenate and sort. Duplicates are preserved:");

            // Concatenate and remove duplicate names based on
            // default string comparer.
            IEnumerable<string> uniqueNamesQuery =
                fileA.Union(fileB).OrderBy(s => s);
            OutputQueryResults(uniqueNamesQuery, "Union removes duplicate names:");

            // Find the names that occur in both files (based on
            // default string comparer).
            IEnumerable<string> commonNamesQuery =
                fileA.Intersect(fileB);
            OutputQueryResults(commonNamesQuery, "Merge based on intersect:");

            // Find the matching fields in each list. Merge the two
            // results by using Concat, and then
            // sort using the default string comparer.
            string nameMatch = "Garcia";

            IEnumerable<String> tempQuery1 =
                from name in fileA
                let n = name.Split(',')
                where n[0] == nameMatch
                select name;

            IEnumerable<string> tempQuery2 =
                from name2 in fileB
                let n2 = name2.Split(',')
                where n2[0] == nameMatch
                select name2;

            IEnumerable<string> nameMatchQuery =
                tempQuery1.Concat(tempQuery2).OrderBy(s => s);
            OutputQueryResults(nameMatchQuery, $"Concat based on partial name match \"{nameMatch}\":");

            // Keep the console window open in debug mode.
            Console.WriteLine("Press any key to exit");
            Console.ReadKey();
        }

        static void OutputQueryResults(IEnumerable<string> query, string message)
        {
            Console.WriteLine(System.Environment.NewLine + message);
            foreach (string item in query)
            {
                Console.WriteLine(item);
            }
            Console.WriteLine("{0} total names in list", query.Count());
        }
    }
    /* Output:
        Simple concatenate and sort. Duplicates are preserved:
        Aw, Kam Foo
        Bankov, Peter
        Bankov, Peter
        Beebe, Ann
        Beebe, Ann
        El Yassir, Mehdi
        Garcia, Debra
        Garcia, Hugo
        Garcia, Hugo
        Giakoumakis, Leo
        Gilchrist, Beth
        Guy, Wey Yuan
        Holm, Michael
        Holm, Michael
        Liu, Jinghao
        McLin, Nkenge
        Myrcha, Jacek
        Noriega, Fabricio
        Potra, Cristina
        Toyoshima, Tim
        20 total names in list
        Union removes duplicate names:
        Aw, Kam Foo
        Bankov, Peter
        Beebe, Ann
        El Yassir, Mehdi
        Garcia, Debra
        Garcia, Hugo
        Giakoumakis, Leo
        Gilchrist, Beth
        Guy, Wey Yuan
        Holm, Michael
        Liu, Jinghao
        McLin, Nkenge
        Myrcha, Jacek
        Noriega, Fabricio
        Potra, Cristina
        Toyoshima, Tim
        16 total names in list

        Merge based on intersect:
        Bankov, Peter
        Holm, Michael
        Garcia, Hugo
        Beebe, Ann
        4 total names in list

        Concat based on partial name match "Garcia":
        Garcia, Debra
        Garcia, Hugo
        Garcia, Hugo
        3 total names in list
*/
```

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher, with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ and Strings (C#)
- LINQ and File Directories (C#)

How to: Populate Object Collections from Multiple Sources (LINQ) (C#)

1/23/2019 • 4 minutes to read • Edit Online

This example shows how to merge data from different sources into a sequence of new types.

NOTE

Don't try to join in-memory data or data in the file system with data that is still in a database. Such cross-domain joins can yield undefined results because of different ways in which join operations might be defined for database queries and other types of sources. Additionally, there is a risk that such an operation could cause an out-of-memory exception if the amount of data in the database is large enough. To join data from a database to in-memory data, first call `ToList` or `ToArray` on the database query, and then perform the join on the returned collection.

To create the data file

Copy the names.csv and scores.csv files into your project folder, as described in How to: Join Content from Dissimilar Files (LINQ) (C#).

Example

The following example shows how to use a named type `Student` to store merged data from two in-memory collections of strings that simulate spreadsheet data in .csv format. The first collection of strings represents the student names and IDs, and the second collection represents the student ID (in the first column) and four exam scores. The ID is used as the foreign key.

```
using System;
using System.Collections.Generic;
using System.Linq;

class Student
{
    public string FirstName { get; set; }
    public string LastName { get; set; }
    public int ID { get; set; }
    public List<int> ExamScores { get; set; }
}

class PopulateCollection
{
    static void Main()
    {
        // These data files are defined in How to: Join Content from
        // Dissimilar Files (LINQ).

        // Each line of names.csv consists of a last name, a first name, and an
        // ID number, separated by commas. For example, Omelchenko,Svetlana,111
        string[] names = System.IO.File.ReadAllLines(@"../../../names.csv");

        // Each line of scores.csv consists of an ID number and four test
        // scores, separated by commas. For example, 111, 97, 92, 81, 60
        string[] scores = System.IO.File.ReadAllLines(@"../../../scores.csv");

        // Merge the data sources using a named type.
        // var could be used instead of an explicit type. Note the dynamic
        // creation of a list of ints for the ExamScores member. The first item
        // is skipped in the split string because it is the student ID,
        // not an exam score.
        IEnumerable<Student> queryNamesScores =
            from nameLine in names
            let splitName = nameLine.Split(',')
            from scoreLine in scores
            let splitScoreLine = scoreLine.Split(',')
            where Convert.ToInt32(splitName[2]) == Convert.ToInt32(splitScoreLine[0])
            select new Student()
            {
                FirstName = splitName[0],
                LastName = splitName[1],
                ID = Convert.ToInt32(splitName[2]),
                ExamScores = (from scoreAsText in splitScoreLine.Skip(1)
                              select Convert.ToInt32(scoreAsText)).
                              ToList()
            };

        // Optional. Store the newly created student objects in memory
        // for faster access in future queries. This could be useful with
        // very large data files.
        List<Student> students = queryNamesScores.ToList();

        // Display each student's name and exam score average.
        foreach (var student in students)
        {
            Console.WriteLine("The average score of {0} {1} is {2}.",
                student.FirstName, student.LastName,
                student.ExamScores.Average());
        }

        //Keep console window open in debug mode
        Console.WriteLine("Press any key to exit.");
        Console.ReadKey();
    }
}
/* Output:
    The average score of Omelchenko Svetlana is 82.5.
    The average score of O'Donnell Claire is 72.25.
    The average score of Mortensen Sven is 84.5.
    The average score of Garcia Cesar is 88.25.
    The average score of Garcia Debra is 67.
    The average score of Fakhouri Fadi is 92.25.
    The average score of Feng Hanying is 88.
    The average score of Garcia Hugo is 85.75.
    The average score of Tucker Lance is 81.75.
    The average score of Adams Terry is 85.25.
    The average score of Zabokritski Eugene is 83.
    The average score of Tucker Michael is 92.
 */
```

In the select clause, an object initializer is used to instantiate each new `Student` object by using the data from the two sources.

If you don't have to store the results of a query, anonymous types can be more convenient than named types. Named types are required if you pass the query results outside the method in which the query is executed. The following example executes the same task as the previous example, but uses anonymous types instead of named types:

```
// Merge the data sources by using an anonymous type.
// Note the dynamic creation of a list of ints for the
// ExamScores member. We skip 1 because the first string
// in the array is the student ID, not an exam score.
var queryNamesScores2 =
    from nameLine in names
    let splitName = nameLine.Split(',')
    from scoreLine in scores
    let splitScoreLine = scoreLine.Split(',')
    where Convert.ToInt32(splitName[2]) == Convert.ToInt32(splitScoreLine[0])
    select new
    {
        First = splitName[0],
        Last = splitName[1],
        ExamScores = (from scoreAsText in splitScoreLine.Skip(1)
                      select Convert.ToInt32(scoreAsText))
                      .ToList()
    };

// Display each student's name and exam score average.
foreach (var student in queryNamesScores2)
{
    Console.WriteLine("The average score of {0} {1} is {2}.",
        student.First, student.Last, student.ExamScores.Average());
}
```

Compiling the code

Create and compile a project that targets one of the following options:

- .NET Framework version 3.5 with a reference to System.Core.dll.
- .NET Framework version 4.0 or higher.
- .NET Core version 1.0 or higher.

See also

- LINQ and Strings (C#)
- Object and Collection Initializers
- Anonymous Types

How to: Split a File Into Many Files by Using Groups (LINQ) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example shows one way to merge the contents of two files and then create a set of new files that organize the data in a new way.

To create the data files

1. Copy these names into a text file that is named names1.txt and save it in your project folder:

```
Bankov, Peter
Holm, Michael
Garcia, Hugo
Potra, Cristina
Noriega, Fabricio
Aw, Kam Foo
Beebe, Ann
Toyoshima, Tim
Guy, Wey Yuan
Garcia, Debra
```

2. Copy these names into a text file that is named names2.txt and save it in your project folder: Note that the two files have some names in common.

```
Liu, Jinghao
Bankov, Peter
Holm, Michael
Garcia, Hugo
Beebe, Ann
Gilchrist, Beth
Myrcha, Jacek
Giakoumakis, Leo
McLin, Nkenge
El Yassir, Mehdi
```

Example

```
class SplitWithGroups
{
    static void Main()
    {
        string[] fileA = System.IO.File.ReadAllLines(@"../../../names1.txt");
        string[] fileB = System.IO.File.ReadAllLines(@"../../../names2.txt");

        // Concatenate and remove duplicate names based on
        // default string comparer
        var mergeQuery = fileA.Union(fileB);

        // Group the names by the first letter in the last name.
        var groupQuery = from name in mergeQuery
                         let n = name.Split(',')
                         group name by n[0][0] into g
                         orderby g.Key
                         select g;
        // Create a new file for each group that was created
        // Note that nested foreach loops are required to access
        // individual items with each group.
        foreach (var g in groupQuery)
        {
            // Create the new file name.
            string fileName = @"../../../testFile_" + g.Key + ".txt";

            // Output to display.
            Console.WriteLine(g.Key);

            // Write file.
            using (System.IO.StreamWriter sw = new System.IO.StreamWriter(fileName))
            {
                foreach (var item in g)
                {
                    sw.WriteLine(item);
                    // Output to console for example purposes.
                    Console.WriteLine("   {0}", item);
                }
            }
        }
        // Keep console window open in debug mode.
        Console.WriteLine("Files have been written. Press any key to exit");
        Console.ReadKey();
    }
}
/* Output:
    A
       Aw, Kam Foo
    B
       Bankov, Peter
       Beebe, Ann
    E
       El Yassir, Mehdi
    G
       Garcia, Hugo
       Guy, Wey Yuan
       Garcia, Debra
       Gilchrist, Beth
       Giakoumakis, Leo
    H
       Holm, Michael
    L
       Liu, Jinghao
    M
       Myrcha, Jacek
       McLin, Nkenge
    N
       Noriega, Fabricio
    P
       Potra, Cristina
    T
       Toyoshima, Tim
 */
```

The program writes a separate file for each group in the same folder as the data files.

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher, with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ and Strings (C#)
- LINQ and File Directories (C#)

How to: Join Content from Dissimilar Files (LINQ) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example shows how to join data from two comma-delimited files that share a common value that is used as a matching key. This technique can be useful if you have to combine data from two spreadsheets, or from a spreadsheet and from a file that has another format, into a new file. You can modify the example to work with any kind of structured text.

To create the data files

1. Copy the following lines into a file that is named *scores.csv* and save it to your project folder. The file represents spreadsheet data. Column 1 is the student's ID, and columns 2 through 5 are test scores.

```
111, 97, 92, 81, 60
112, 75, 84, 91, 39
113, 88, 94, 65, 91
114, 97, 89, 85, 82
115, 35, 72, 91, 70
116, 99, 86, 90, 94
117, 93, 92, 80, 87
118, 92, 90, 83, 78
119, 68, 79, 88, 92
120, 99, 82, 81, 79
121, 96, 85, 91, 60
122, 94, 92, 91, 91
```

2. Copy the following lines into a file that is named *names.csv* and save it to your project folder. The file represents a spreadsheet that contains the student's last name, first name, and student ID.

```
Omelchenko,Svetlana,111
O'Donnell,Claire,112
Mortensen,Sven,113
Garcia,Cesar,114
Garcia,Debra,115
Fakhouri,Fadi,116
Feng,Hanying,117
Garcia,Hugo,118
Tucker,Lance,119
Adams,Terry,120
Zabokritski,Eugene,121
Tucker,Michael,122
```

Example

```
using System;
using System.Collections.Generic;
using System.Linq;

class JoinStrings
{
    static void Main()
    {
        // Join content from dissimilar files that contain
        // related information. File names.csv contains the student
        // name plus an ID number. File scores.csv contains the ID
        // and a set of four test scores. The following query joins
        // the scores to the student names by using ID as a
        // matching key.

        string[] names = System.IO.File.ReadAllLines(@"../../../names.csv");
        string[] scores = System.IO.File.ReadAllLines(@"../../../scores.csv");

        // Name:    Last[0],       First[1],  ID[2]
        //          Omelchenko,    Svetlana,  11
        // Score:   StudentID[0],  Exam1[1]   Exam2[2],  Exam3[3],  Exam4[4]
        //          111,           97,        92,        81,        60

        // This query joins two dissimilar spreadsheets based on common ID value.
        // Multiple from clauses are used instead of a join clause
        // in order to store results of id.Split.
        IEnumerable<string> scoreQuery1 =
            from name in names
            let nameFields = name.Split(',')
            from id in scores
            let scoreFields = id.Split(',')
            where Convert.ToInt32(nameFields[2]) == Convert.ToInt32(scoreFields[0])
            select nameFields[0] + "," + scoreFields[1] + "," + scoreFields[2]
                   + "," + scoreFields[3] + "," + scoreFields[4];

        // Pass a query variable to a method and execute it
        // in the method. The query itself is unchanged.
        OutputQueryResults(scoreQuery1, "Merge two spreadsheets:");

        // Keep console window open in debug mode.
        Console.WriteLine("Press any key to exit");
        Console.ReadKey();
    }

    static void OutputQueryResults(IEnumerable<string> query, string message)
    {
        Console.WriteLine(System.Environment.NewLine + message);
        foreach (string item in query)
        {
            Console.WriteLine(item);
        }
        Console.WriteLine("{0} total names in list", query.Count());
    }
}
/* Output:
Merge two spreadsheets:
Omelchenko, 97, 92, 81, 60
O'Donnell, 75, 84, 91, 39
Mortensen, 88, 94, 65, 91
Garcia, 97, 89, 85, 82
Garcia, 35, 72, 91, 70
Fakhouri, 99, 86, 90, 94
Feng, 93, 92, 80, 87
Garcia, 92, 90, 83, 78
Tucker, 68, 79, 88, 92
Adams, 99, 82, 81, 79
Zabokritski, 96, 85, 91, 60
Tucker, 94, 92, 91, 91
12 total names in list
 */
```

Compiling the code

Create and compile a project that targets one of the following options:

- .NET Framework version 3.5 with a reference to System.Core.dll.
- .NET Framework version 4.0 or higher.
- .NET Core version 1.0 or higher.

See also

- LINQ and Strings (C#)
- LINQ and File Directories (C#)

How to: Compute Column Values in a CSV Text File (LINQ) (C#)

1/23/2019 • 3 minutes to read • Edit Online

This example shows how to perform aggregate computations such as Sum, Average, Min, and Max on the columns of a .csv file. The example principles that are shown here can be applied to other types of structured text.

To create the source file

1. Copy the following lines into a file that is named scores.csv and save it in your project folder. Assume that the first column represents a student ID, and subsequent columns represent scores from four exams.

```
111, 97, 92, 81, 60
112, 75, 84, 91, 39
113, 88, 94, 65, 91
114, 97, 89, 85, 82
115, 35, 72, 91, 70
116, 99, 86, 90, 94
117, 93, 92, 80, 87
118, 92, 90, 83, 78
119, 68, 79, 88, 92
120, 99, 82, 81, 79
121, 96, 85, 91, 60
122, 94, 92, 91, 91
```

Example

```
class SumColumns
{
    static void Main(string[] args)
    {
        string[] lines = System.IO.File.ReadAllLines(@"../../../scores.csv");

        // Specifies the column to compute.
        int exam = 3;

        // Spreadsheet format:
        // Student ID    Exam#1  Exam#2  Exam#3  Exam#4
        // 111,          97,     92,     81,     60

        // Add one to exam to skip over the first column,
        // which holds the student ID.
        SingleColumn(lines, exam + 1);
        Console.WriteLine();
        MultiColumns(lines);

        Console.WriteLine("Press any key to exit");
        Console.ReadKey();
    }

    static void SingleColumn(IEnumerable<string> strs, int examNum)
    {
        Console.WriteLine("Single Column Query:");

        // Parameter examNum specifies the column to
        // run the calculations on. This value could be
        // passed in dynamically at runtime.
        // Variable columnQuery is an IEnumerable<int>.
        // The following query performs two steps:
        // 1) use Split to break each row (a string) into an array
        //    of strings,
        // 2) convert the element at position examNum to an int
        //    and select it.
        var columnQuery =
            from line in strs
            let elements = line.Split(',')
            select Convert.ToInt32(elements[examNum]);

        // Execute the query and cache the results to improve
        // performance. This is helpful only with very large files.
        var results = columnQuery.ToList();

        // Perform aggregate calculations Average, Max, and
        // Min on the column specified by examNum.
        double average = results.Average();
        int max = results.Max();
        int min = results.Min();

        Console.WriteLine("Exam #{0}: Average:{1:##.##} High Score:{2} Low Score:{3}",
                 examNum, average, max, min);
    }

    static void MultiColumns(IEnumerable<string> strs)
    {
        Console.WriteLine("Multi Column Query:");

        // Create a query, multiColQuery. Explicit typing is used
        // to make clear that, when executed, multiColQuery produces
        // nested sequences. However, you get the same results by
        // using 'var'.

        // The multiColQuery query performs the following steps:
        // 1) use Split to break each row (a string) into an array
        //    of strings,
        // 2) use Skip to skip the "Student ID" column, and store the
        //    rest of the row in scores.
        // 3) convert each score in the current row from a string to
        //    an int, and select that entire sequence as one row
        //    in the results.
        IEnumerable<IEnumerable<int>> multiColQuery =
            from line in strs
            let elements = line.Split(',')
            let scores = elements.Skip(1)
            select (from str in scores
                    select Convert.ToInt32(str));

        // Execute the query and cache the results to improve
        // performance.
        // ToArray could be used instead of ToList.
        var results = multiColQuery.ToList();

        // Find out how many columns you have in results.
        int columnCount = results[0].Count();

        // Perform aggregate calculations Average, Max, and
        // Min on each column.
        // Perform one iteration of the loop for each column
        // of scores.
        // You can use a for loop instead of a foreach loop
        // because you already executed the multiColQuery
        // query by calling ToList.
        for (int column = 0; column < columnCount; column++)
        {
            var results2 = from row in results
                           select row.ElementAt(column);
            double average = results2.Average();
            double average = results2.Average();
            int max = results2.Max();
            int min = results2.Min();

            // Add one to column because the first exam is Exam #1,
            // not Exam #0.
            Console.WriteLine("Exam #{0} Average: {1:##.##} High Score: {2} Low Score: {3}",
                          column + 1, average, max, min);
        }
    }
}
/* Output:
    Single Column Query:
    Exam #4: Average:76.92 High Score:94 Low Score:39

    Multi Column Query:
    Exam #1 Average: 86.08 High Score: 99 Low Score: 35
    Exam #2 Average: 86.42 High Score: 94 Low Score: 72
    Exam #3 Average: 84.75 High Score: 91 Low Score: 65
    Exam #4 Average: 76.92 High Score: 94 Low Score: 39
 */
```

The query works by using the Split method to convert each line of text into an array. Each array element represents a column. Finally, the text in each column is converted to its numeric representation. If your file is a tab-separated file, just update the argument in the `Split` method to `\t`.

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher, with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ and Strings (C#)
- LINQ and File Directories (C#)

LINQ and Reflection (C#)

1/23/2019 • 2 minutes to read • Edit Online

The .NET Framework class library reflection APIs can be used to examine the metadata in a .NET assembly and create collections of types, type members, parameters, and so on that are in that assembly. Because these collections support the generic `IEnumerable` interface, they can be queried by using LINQ.

This section contains the following topics:

How to: Query An Assembly's Metadata with Reflection (LINQ) (C#)
Shows how to use LINQ with reflection.

See also

- LINQ to Objects (C#)

How to: Query An Assembly's Metadata with Reflection (LINQ) (C#)

1/30/2019 • 2 minutes to read • Edit Online

The following example shows how LINQ can be used with reflection to retrieve specific metadata about methods that match a specified search criterion. In this case, the query will find the names of all the methods in the assembly that return enumerable types such as arrays.

Example

```
using System.Reflection;
using System.IO;
namespace LINQReflection
{
    class ReflectionHowTO
    {
        static void Main(string[] args)
        {
            Assembly assembly = Assembly.Load("System.Core, Version=3.5.0.0, Culture=neutral, PublicKeyToken=
b77a5c561934e089");
            var pubTypesQuery = from type in assembly.GetTypes()
                        where type.IsPublic
                            from method in type.GetMethods()
                            where method.ReturnType.IsArray == true
                                || ( method.ReturnType.GetInterface(
                                    typeof(System.Collections.Generic.IEnumerable<>).FullName ) != null
                                && method.ReturnType.FullName != "System.String" )
                            group method.ToString() by type.ToString();

            foreach (var groupOfMethods in pubTypesQuery)
            {
                Console.WriteLine("Type: {0}", groupOfMethods.Key);
                foreach (var method in groupOfMethods)
                {
                    Console.WriteLine("  {0}", method);
                }
            }

            Console.WriteLine("Press any key to exit");
            Console.ReadKey();
        }
    }
}
```

The example uses the GetTypes method to return an array of types in the specified assembly. The where filter is applied so that only public types are returned. For each public type, a subquery is generated by using the MethodInfo array that is returned from the GetMethods call. These results are filtered to return only those methods whose return type is an array or else a type that implements IEnumerable<T>. Finally, these results are grouped by using the type name as a key.

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ to Objects (C#)

LINQ and File Directories (C#)

1/23/2019 • 2 minutes to read • Edit Online

Many file system operations are essentially queries and are therefore well-suited to the LINQ approach.

Note that the queries in this section are non-destructive. They are not used to change the contents of the original files or folders. This follows the rule that queries should not cause any side-effects. In general, any code (including queries that perform create / update / delete operators) that modifies source data should be kept separate from the code that just queries the data.

This section contains the following topics:

How to: Query for Files with a Specified Attribute or Name (C#)
Shows how to search for files by examining one or more properties of its FileInfo object.

How to: Group Files by Extension (LINQ) (C#)
Shows how to return groups of FileInfo object based on their file name extension.

How to: Query for the Total Number of Bytes in a Set of Folders (LINQ) (C#)
Shows how to return the total number of bytes in all the files in a specified directory tree.

How to: Compare the Contents of Two Folders (LINQ) (C#)s
Shows how to return all the files that are present in two specified folders, and also all the files that are present in one folder but not the other.

How to: Query for the Largest File or Files in a Directory Tree (LINQ) (C#)
Shows how to return the largest or smallest file, or a specified number of files, in a directory tree.

How to: Query for Duplicate Files in a Directory Tree (LINQ) (C#)
Shows how to group for all file names that occur in more than one location in a specified directory tree. Also shows how to perform more complex comparisons based on a custom comparer.

How to: Query the Contents of Files in a Folder (LINQ) (C#)
Shows how to iterate through folders in a tree, open each file, and query the file's contents.

Comments

There is some complexity involved in creating a data source that accurately represents the contents of the file system and handles exceptions gracefully. The examples in this section create a snapshot collection of FileInfo objects that represents all the files under a specified root folder and all its subfolders. The actual state of each FileInfo may change in the time between when you begin and end executing a query. For example, you can create a list of FileInfo objects to use as a data source. If you try to access the `Length` property in a query, the FileInfo object will try to access the file system to update the value of `Length`. If the file no longer exists, you will get a FileNotFoundException in your query, even though you are not querying the file system directly. Some queries in this section use a separate method that consumes these particular exceptions in certain cases. Another option is to keep your data source updated dynamically by using the FileSystemWatcher.

See also

- LINQ to Objects (C#)

How to: Query for Files with a Specified Attribute or Name (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example shows how to find all files that have a specified file name extension (for example ".txt") in a specified directory tree. It also shows how to return either the newest or oldest file in the tree based on the creation time.

Example

```
class FindFileByExtension
{
    // This query will produce the full path for all .txt files
    // under the specified folder including subfolders.
    // It orders the list according to the file name.
    static void Main()
    {
        string startFolder = @"c:\program files\Microsoft Visual Studio 9.0\";

        // Take a snapshot of the file system.
        System.IO.DirectoryInfo dir = new System.IO.DirectoryInfo(startFolder);

        // This method assumes that the application has discovery permissions
        // for all folders under the specified path.
        IEnumerable<System.IO.FileInfo> fileList = dir.GetFiles("*.*", System.IO.SearchOption.AllDirectories);

        //Create the query
        IEnumerable<System.IO.FileInfo> fileQuery =
            from file in fileList
            where file.Extension == ".txt"
            orderby file.Name
            select file;

        //Execute the query. This might write out a lot of files!
        foreach (System.IO.FileInfo fi in fileQuery)
        {
            Console.WriteLine(fi.FullName);
        }

        // Create and execute a new query by using the previous
        // query as a starting point. fileQuery is not
        // executed again until the call to Last()
        var newestFile =
            (from file in fileQuery
             orderby file.CreationTime
             select new { file.FullName, file.CreationTime })
            .Last();

        Console.WriteLine("\r\nThe newest .txt file is {0}. Creation time: {1}",
            newestFile.FullName, newestFile.CreationTime);

        // Keep the console window open in debug mode.
        Console.WriteLine("Press any key to exit");
        Console.ReadKey();
    }
}
```

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher, with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ to Objects (C#)
- LINQ and File Directories (C#)

How to: Group Files by Extension (LINQ) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example shows how LINQ can be used to perform advanced grouping and sorting operations on lists of files or folders. It also shows how to page output in the console window by using the Skip and Take methods.

Example

The following query shows how to group the contents of a specified directory tree by the file name extension.

```
class GroupByExtension
{
    // This query will sort all the files under the specified folder
    //  and subfolder into groups keyed by the file extension.
    private static void Main()
    {
        // Take a snapshot of the file system.
        string startFolder = @"c:\program files\Microsoft Visual Studio 9.0\Common7";

        // Used in WriteLine to trim output lines.
        int trimLength = startFolder.Length;

        // Take a snapshot of the file system.
        System.IO.DirectoryInfo dir = new System.IO.DirectoryInfo(startFolder);

        // This method assumes that the application has discovery permissions
        // for all folders under the specified path.
        IEnumerable<System.IO.FileInfo> fileList = dir.GetFiles("*.*", System.IO.SearchOption.AllDirectories);

        // Create the query.
        var queryGroupByExt =
            from file in fileList
            group file by file.Extension.ToLower() into fileGroup
            orderby fileGroup.Key
            select fileGroup;

        // Display one group at a time. If the number of
        // entries is greater than the number of lines
        // in the console window, then page the output.
        PageOutput(trimLength, queryGroupByExt);
    }

    // This method specifically handles group queries of FileInfo objects with string keys.
    // It can be modified to work for any long listings of data. Note that explicit typing
    // must be used in method signatures. The groupbyExtList parameter is a query that produces
    // groups of FileInfo objects with string keys.
    private static void PageOutput(int rootLength,
                                    IEnumerable<System.Linq.IGrouping<string, System.IO.FileInfo>>
groupByExtList)
    {
        // Flag to break out of paging loop.
        bool goAgain = true;

        // "3" = 1 line for extension + 1 for "Press any key" + 1 for input cursor.
        int numLines = Console.WindowHeight - 3;

        // Iterate through the outer collection of groups.
        foreach (var filegroup in groupByExtList)
        {
            // Start a new extension at the top of a page.
            int currentLine = 0;
```

```
                // Output only as many lines of the current group as will fit in the window.
                do
                {
                    Console.Clear();
                    Console.WriteLine(filegroup.Key == String.Empty ? "[none]" : filegroup.Key);

                    // Get 'numLines' number of items starting at number 'currentLine'.
                    var resultPage = filegroup.Skip(currentLine).Take(numLines);

                    //Execute the resultPage query
                    foreach (var f in resultPage)
                    {
                        Console.WriteLine("\t{0}", f.FullName.Substring(rootLength));
                    }

                    // Increment the line counter.
                    currentLine += numLines;

                    // Give the user a chance to escape.
                    Console.WriteLine("Press any key to continue or the 'End' key to break...");
                    ConsoleKey key = Console.ReadKey().Key;
                    if (key == ConsoleKey.End)
                    {
                        goAgain = false;
                        break;
                    }
                } while (currentLine < filegroup.Count());

                if (goAgain == false)
                    break;
            }
        }
    }
```

The output from this program can be long, depending on the details of the local file system and what the `startFolder` is set to. To enable viewing of all results, this example shows how to page through results. The same techniques can be applied to Windows and Web applications. Notice that because the code pages the items in a group, a nested `foreach` loop is required. There is also some additional logic to compute the current position in the list, and to enable the user to stop paging and exit the program. In this particular case, the paging query is run against the cached results from the original query. In other contexts, such as LINQ to SQL, such caching is not required.

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher, with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ to Objects (C#)
- LINQ and File Directories (C#)

How to: Query for the Total Number of Bytes in a Set of Folders (LINQ) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example shows how to retrieve the total number of bytes used by all the files in a specified folder and all its subfolders.

Example

The Sum method adds the values of all the items selected in the `select` clause. You can easily modify this query to retrieve the biggest or smallest file in the specified directory tree by calling the Min or Max method instead of Sum.

```
class QuerySize
{
    public static void Main()
    {
        string startFolder = @"c:\program files\Microsoft Visual Studio 9.0\VC#";

        // Take a snapshot of the file system.
        // This method assumes that the application has discovery permissions
        // for all folders under the specified path.
        IEnumerable<string> fileList = System.IO.Directory.GetFiles(startFolder, "*.*",
System.IO.SearchOption.AllDirectories);

        var fileQuery = from file in fileList
                        select GetFileLength(file);

        // Cache the results to avoid multiple trips to the file system.
        long[] fileLengths = fileQuery.ToArray();

        // Return the size of the largest file
        long largestFile = fileLengths.Max();

        // Return the total number of bytes in all the files under the specified folder.
        long totalBytes = fileLengths.Sum();

        Console.WriteLine("There are {0} bytes in {1} files under {2}",
            totalBytes, fileList.Count(), startFolder);
        Console.WriteLine("The largest files is {0} bytes.", largestFile);

        // Keep the console window open in debug mode.
        Console.WriteLine("Press any key to exit.");
        Console.ReadKey();
    }

    // This method is used to swallow the possible exception
    // that can be raised when accessing the System.IO.FileInfo.Length property.
    static long GetFileLength(string filename)
    {
        long retval;
        try
        {
            System.IO.FileInfo fi = new System.IO.FileInfo(filename);
            retval = fi.Length;
        }
        catch (System.IO.FileNotFoundException)
        {
            // If a file is no longer present,
            // just add zero bytes to the total.
            retval = 0;
        }
        return retval;
    }
}
```

If you only have to count the number of bytes in a specified directory tree, you can do this more efficiently without creating a LINQ query, which incurs the overhead of creating the list collection as a data source. The usefulness of the LINQ approach increases as the query becomes more complex, or when you have to run multiple queries against the same data source.

The query calls out to a separate method to obtain the file length. It does this in order to consume the possible exception that will be raised if the file was deleted on another thread after the FileInfo object was created in the call to `GetFiles`. Even though the FileInfo object has already been created, the exception can occur because a FileInfo object will try to refresh its Length property with the most current length the first time the property is accessed. By putting this operation in a try-catch block outside the query, the code follows the rule of avoiding operations in queries that can cause side-effects. In general, great care must be taken when you consume exceptions to make sure that an application is not left in an unknown state.

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher, with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ to Objects (C#)
- LINQ and File Directories (C#)

How to: Compare the Contents of Two Folders (LINQ) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example demonstrates three ways to compare two file listings:

- By querying for a Boolean value that specifies whether the two file lists are identical.
- By querying for the intersection to retrieve the files that are in both folders.
- By querying for the set difference to retrieve the files that are in one folder but not the other.

> **NOTE**
>
> The techniques shown here can be adapted to compare sequences of objects of any type.

The `FileComparer` class shown here demonstrates how to use a custom comparer class together with the Standard Query Operators. The class is not intended for use in real-world scenarios. It just uses the name and length in bytes of each file to determine whether the contents of each folder are identical or not. In a real-world scenario, you should modify this comparer to perform a more rigorous equality check.

Example

```
namespace QueryCompareTwoDirs
{
    class CompareDirs
    {

        static void Main(string[] args)
        {

            // Create two identical or different temporary folders
            // on a local drive and change these file paths.
            string pathA = @"C:\TestDir";
            string pathB = @"C:\TestDir2";

            System.IO.DirectoryInfo dir1 = new System.IO.DirectoryInfo(pathA);
            System.IO.DirectoryInfo dir2 = new System.IO.DirectoryInfo(pathB);

            // Take a snapshot of the file system.
            IEnumerable<System.IO.FileInfo> list1 = dir1.GetFiles("*.*",
System.IO.SearchOption.AllDirectories);
            IEnumerable<System.IO.FileInfo> list2 = dir2.GetFiles("*.*",
System.IO.SearchOption.AllDirectories);

            //A custom file comparer defined below
            FileCompare myFileCompare = new FileCompare();

            // This query determines whether the two folders contain
            // identical file lists, based on the custom file comparer
            // that is defined in the FileCompare class.
            // The query executes immediately because it returns a bool.
            bool areIdentical = list1.SequenceEqual(list2, myFileCompare);

            if (areIdentical == true)
            {
                Console.WriteLine("the two folders are the same");
                Console.WriteLine("the two folders are the same");
            }
            else
            {
                Console.WriteLine("The two folders are not the same");
            }

            // Find the common files. It produces a sequence and doesn't
            // execute until the foreach statement.
            var queryCommonFiles = list1.Intersect(list2, myFileCompare);

            if (queryCommonFiles.Count() > 0)
            {
                Console.WriteLine("The following files are in both folders:");
                foreach (var v in queryCommonFiles)
                {
                    Console.WriteLine(v.FullName); //shows which items end up in result list
                }
            }
            else
            {
                Console.WriteLine("There are no common files in the two folders.");
            }

            // Find the set difference between the two folders.
            // For this example we only check one way.
            var queryList1Only = (from file in list1
                                  select file).Except(list2, myFileCompare);

            Console.WriteLine("The following files are in list1 but not list2:");
            foreach (var v in queryList1Only)
            {
                Console.WriteLine(v.FullName);
            }

            // Keep the console window open in debug mode.
            Console.WriteLine("Press any key to exit.");
            Console.ReadKey();
        }
    }

    // This implementation defines a very simple comparison
    // between two FileInfo objects. It only compares the name
    // of the files being compared and their length in bytes.
    class FileCompare : System.Collections.Generic.IEqualityComparer<System.IO.FileInfo>
    {
        public FileCompare() { }

        public bool Equals(System.IO.FileInfo f1, System.IO.FileInfo f2)
        {
            return (f1.Name == f2.Name &&
                    f1.Length == f2.Length);
        }

        // Return a hash that reflects the comparison criteria. According to the
        // rules for IEqualityComparer<T>, if Equals is true, then the hash codes must
        // also be equal. Because equality as defined here is a simple value equality, not
        // reference identity, it is possible that two or more objects will produce the same
        // hash code.
        public int GetHashCode(System.IO.FileInfo fi)
        {
            string s = $"{fi.Name}{fi.Length}";
            return s.GetHashCode();
        }
    }
}
```

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher, with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ to Objects (C#)
- LINQ and File Directories (C#)

How to: Query for the Largest File or Files in a Directory Tree (LINQ) (C#)

1/23/2019 • 3 minutes to read • Edit Online

This example shows five queries related to file size in bytes:

- How to retrieve the size in bytes of the largest file.
- How to retrieve the size in bytes of the smallest file.
- How to retrieve the FileInfo object largest or smallest file from one or more folders under a specified root folder.
- How to retrieve a sequence such as the 10 largest files.
- How to order files into groups based on their file size in bytes, ignoring files that are less than a specified size.

Example

The following example contains five separate queries that show how to query and group files, depending on their file size in bytes. You can easily modify these examples to base the query on some other property of the FileInfo object.

```
class QueryBySize
{
    static void Main(string[] args)
    {
        QueryFilesBySize();
        Console.WriteLine("Press any key to exit");
        Console.ReadKey();
    }

    private static void QueryFilesBySize()
    {
        string startFolder = @"c:\program files\Microsoft Visual Studio 9.0\";

        // Take a snapshot of the file system.
        System.IO.DirectoryInfo dir = new System.IO.DirectoryInfo(startFolder);

        // This method assumes that the application has discovery permissions
        // for all folders under the specified path.
        IEnumerable<System.IO.FileInfo> fileList = dir.GetFiles("*.*", System.IO.SearchOption.AllDirectories);

        //Return the size of the largest file
        long maxSize =
            (from file in fileList
             let len = GetFileLength(file)
             select len)
             .Max();

        Console.WriteLine("The length of the largest file under {0} is {1}",
            startFolder, maxSize);

        // Return the FileInfo object for the largest file
        // by sorting and selecting from beginning of list
        System.IO.FileInfo longestFile =
            (from file in fileList
             let len = GetFileLength(file)
             where len > 0
             orderby len descending
             select file)
            .First();

        Console.WriteLine("The largest file under {0} is {1} with a length of {2} bytes",
                            startFolder, longestFile.FullName, longestFile.Length);

        //Return the FileInfo of the smallest file
        System.IO.FileInfo smallestFile =
            (from file in fileList
             let len = GetFileLength(file)
             where len > 0
             orderby len ascending
             select file).First();

        Console.WriteLine("The smallest file under {0} is {1} with a length of {2} bytes",
                            startFolder, smallestFile.FullName, smallestFile.Length);

        //Return the FileInfos for the 10 largest files
        // queryTenLargest is an IEnumerable<System.IO.FileInfo>
        var queryTenLargest =
            (from file in fileList
             let len = GetFileLength(file)
             orderby len descending
             select file).Take(10);

        Console.WriteLine("The 10 largest files under {0} are:", startFolder);

        foreach (var v in queryTenLargest)
        {
            Console.WriteLine("{0}: {1} bytes", v.FullName, v.Length);
        }

        // Group the files according to their size, leaving out
        // files that are less than 200000 bytes.
        var querySizeGroups =
            from file in fileList
            let len = GetFileLength(file)
            where len > 0
            group file by (len / 100000) into fileGroup
            where fileGroup.Key >= 2
            orderby fileGroup.Key descending
            select fileGroup;

        foreach (var filegroup in querySizeGroups)
        {
            Console.WriteLine(filegroup.Key.ToString() + "00000");
            foreach (var item in filegroup)
            {
                Console.WriteLine("\t{0}: {1}", item.Name, item.Length);
            }
        }
    }

    // This method is used to swallow the possible exception
    // that can be raised when accessing the FileInfo.Length property.
    // In this particular case, it is safe to swallow the exception.
    static long GetFileLength(System.IO.FileInfo fi)
    {
        long retval;
        try
        {
            retval = fi.Length;
        }
        catch (System.IO.FileNotFoundException)
        {
            // If a file is no longer present,
            // just add zero bytes to the total.
            retval = 0;
        }
        return retval;
    }

}
```

To return one or more complete FileInfo objects, the query first must examine each one in the data source, and then sort them by the value of their Length property. Then it can return the single one or the sequence with the greatest lengths. Use First to return the first element in a list. Use Take to return the first n number of elements. Specify a descending sort order to put the smallest elements at the start of the list.

The query calls out to a separate method to obtain the file size in bytes in order to consume the possible exception that will be raised in the case where a file was deleted on another thread in the time period since the FileInfo object was created in the call to `GetFiles`. Even through the FileInfo object has already been created, the exception can occur because a FileInfo object will try to refresh its Length property by using the most current size in bytes the first time the property is accessed. By putting this operation in a try-catch block outside the query, we follow the rule of avoiding operations in queries that can cause side-effects. In general, great care must be taken when consuming exceptions, to make sure that an application is not left in an unknown state.

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher, with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ to Objects (C#)
- LINQ and File Directories (C#)

How to: Query for Duplicate Files in a Directory Tree (LINQ) (C#)

1/23/2019 • 3 minutes to read • Edit Online

Sometimes files that have the same name may be located in more than one folder. For example, under the Visual Studio installation folder, several folders have a readme.htm file. This example shows how to query for such duplicate file names under a specified root folder. The second example shows how to query for files whose size and creation times also match.

Example

```
class QueryDuplicateFileNames
{
    static void Main(string[] args)
    {
        // Uncomment QueryDuplicates2 to run that query.
        QueryDuplicates();
        // QueryDuplicates2();

        // Keep the console window open in debug mode.
        Console.WriteLine("Press any key to exit.");
        Console.ReadKey();
    }

    static void QueryDuplicates()
    {
        // Change the root drive or folder if necessary
        string startFolder = @"c:\program files\Microsoft Visual Studio 9.0\";

        // Take a snapshot of the file system.
        System.IO.DirectoryInfo dir = new System.IO.DirectoryInfo(startFolder);

        // This method assumes that the application has discovery permissions
        // for all folders under the specified path.
        IEnumerable<System.IO.FileInfo> fileList = dir.GetFiles("*.*", System.IO.SearchOption.AllDirectories);

        // used in WriteLine to keep the lines shorter
        int charsToSkip = startFolder.Length;

        // var can be used for convenience with groups.
        var queryDupNames =
            from file in fileList
            group file.FullName.Substring(charsToSkip) by file.Name into fileGroup
            where fileGroup.Count() > 1
            select fileGroup;

        // Pass the query to a method that will
        // output one page at a time.
        PageOutput<string, string>(queryDupNames);
    }

    // A Group key that can be passed to a separate method.
    // Override Equals and GetHashCode to define equality for the key.
    // Override ToString to provide a friendly name for Key.ToString()
    class PortableKey
    {
        public string Name { get; set; }
        public DateTime CreationTime { get; set; }
        public long Length { get; set; }
        public override bool Equals(object obj)
        {
            PortableKey other = (PortableKey)obj;
            return other.CreationTime == this.CreationTime &&
                   other.Length == this.Length &&
                   other.Name == this.Name;
        }

        public override int GetHashCode()
        {
            string str = $"{this.CreationTime}{this.Length}{this.Name}";
            return str.GetHashCode();
        }
        public override string ToString()
        {
            return $"{this.Name} {this.Length} {this.CreationTime}";
        }
    }
    static void QueryDuplicates2()
    {
        // Change the root drive or folder if necessary.
        string startFolder = @"c:\program files\Microsoft Visual Studio 9.0\Common7";

        // Make the lines shorter for the console display
        int charsToSkip = startFolder.Length;

        // Take a snapshot of the file system.
        System.IO.DirectoryInfo dir = new System.IO.DirectoryInfo(startFolder);
        IEnumerable<System.IO.FileInfo> fileList = dir.GetFiles("*.*", System.IO.SearchOption.AllDirectories);

        // Note the use of a compound key. Files that match
        // all three properties belong to the same group.
        // A named type is used to enable the query to be
        // passed to another method. Anonymous types can also be used
        // for composite keys but cannot be passed across method boundaries
        //
        var queryDupFiles =
            from file in fileList
            group file.FullName.Substring(charsToSkip) by
                new PortableKey { Name = file.Name, CreationTime = file.CreationTime, Length = file.Length }
into fileGroup
            where fileGroup.Count() > 1
            select fileGroup;

        var list = queryDupFiles.ToList();

        int i = queryDupFiles.Count();

        PageOutput<PortableKey, string>(queryDupFiles);
    }

    // A generic method to page the output of the QueryDuplications methods
    // Here the type of the group must be specified explicitly. "var" cannot
    // be used in method signatures. This method does not display more than one
    // group per page.
    private static void PageOutput<K, V>(IEnumerable<System.Linq.IGrouping<K, V>> groupByExtList)
    {
        // Flag to break out of paging loop.
        bool goAgain = true;

        // "3" = 1 line for extension + 1 for "Press any key" + 1 for input cursor.
        int numLines = Console.WindowHeight - 3;

        // Iterate through the outer collection of groups.
        foreach (var filegroup in groupByExtList)
        {
            // Start a new extension at the top of a page.
            int currentLine = 0;
            // Output only as many lines of the current group as will fit in the window.
            do
            {
                Console.Clear();
                Console.WriteLine("Filename = {0}", filegroup.Key.ToString() == String.Empty ? "[none]" :
filegroup.Key.ToString());

                // Get 'numLines' number of items starting at number 'currentLine'.
                var resultPage = filegroup.Skip(currentLine).Take(numLines);

                //Execute the resultPage query
                foreach (var fileName in resultPage)
                {
                    Console.WriteLine("\t{0}", fileName);
                }

                // Increment the line counter.
                currentLine += numLines;

                // Give the user a chance to escape.
                Console.WriteLine("Press any key to continue or the 'End' key to break...");
                ConsoleKey key = Console.ReadKey().Key;
                if (key == ConsoleKey.End)
                {
                    goAgain = false;
                    break;
                }
            } while (currentLine < filegroup.Count());

            if (goAgain == false)
                break;
        }
    }
}
```

The first query uses a simple key to determine a match; this finds files that have the same name but whose contents might be different. The second query uses a compound key to match against three properties of the FileInfo object. This query is much more likely to find files that have the same name and similar or identical content.

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher, with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ to Objects (C#)
- LINQ and File Directories (C#)

How to: Query the Contents of Text Files in a Folder (LINQ) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example shows how to query over all the files in a specified directory tree, open each file, and inspect its contents. This type of technique could be used to create indexes or reverse indexes of the contents of a directory tree. A simple string search is performed in this example. However, more complex types of pattern matching can be performed with a regular expression. For more information, see How to: Combine LINQ Queries with Regular Expressions (C#).

Example

```
class QueryContents
{
    public static void Main()
    {
        // Modify this path as necessary.
        string startFolder = @"c:\program files\Microsoft Visual Studio 9.0\";

        // Take a snapshot of the file system.
        System.IO.DirectoryInfo dir = new System.IO.DirectoryInfo(startFolder);

        // This method assumes that the application has discovery permissions
        // for all folders under the specified path.
        IEnumerable<System.IO.FileInfo> fileList = dir.GetFiles("*.*", System.IO.SearchOption.AllDirectories);

        string searchTerm = @"Visual Studio";

        // Search the contents of each file.
        // A regular expression created with the RegEx class
        // could be used instead of the Contains method.
        // queryMatchingFiles is an IEnumerable<string>.
        var queryMatchingFiles =
            from file in fileList
            where file.Extension == ".htm"
            let fileText = GetFileText(file.FullName)
            where fileText.Contains(searchTerm)
            select file.FullName;

        // Execute the query.
        Console.WriteLine("The term \"{0}\" was found in:", searchTerm);
        foreach (string filename in queryMatchingFiles)
        {
            Console.WriteLine(filename);
        }

        // Keep the console window open in debug mode.
        Console.WriteLine("Press any key to exit");
        Console.ReadKey();
    }

    // Read the contents of the file.
    static string GetFileText(string name)
    {
        string fileContents = String.Empty;

        // If the file has been deleted since we took
        // the snapshot, ignore it and return the empty string.
        if (System.IO.File.Exists(name))
        {
            fileContents = System.IO.File.ReadAllText(name);
        }
        return fileContents;
    }
}
```

Compiling the Code

Create a project that targets the .NET Framework version 3.5 or higher, with a reference to System.Core.dll and `using` directives for the System.Linq and System.IO namespaces.

See also

- LINQ and File Directories (C#)
- LINQ to Objects (C#)

How to: Query an ArrayList with LINQ (C#)

1/23/2019 • 2 minutes to read • Edit Online

When using LINQ to query non-generic IEnumerable collections such as ArrayList, you must explicitly declare the type of the range variable to reflect the specific type of the objects in the collection. For example, if you have an ArrayList of `Student` objects, your from clause should look like this:

```
var query = from Student s in arrList
...
```

By specifying the type of the range variable, you are casting each item in the ArrayList to a `Student`.

The use of an explicitly typed range variable in a query expression is equivalent to calling the Cast method. Cast throws an exception if the specified cast cannot be performed. Cast and OfType are the two Standard Query Operator methods that operate on non-generic IEnumerable types. For more information, see Type Relationships in LINQ Query Operations.

Example

The following example shows a simple query over an ArrayList. Note that this example uses object initializers when the code calls the Add method, but this is not a requirement.

```
using System;
using System.Collections;
using System.Linq;

namespace NonGenericLINQ
{
    public class Student
    {
        public string FirstName { get; set; }
        public string LastName { get; set; }
        public int[] Scores { get; set; }
    }

    class Program
    {
        static void Main(string[] args)
        {
            ArrayList arrList = new ArrayList();
            arrList.Add(
                new Student
                    {
                        FirstName = "Svetlana", LastName = "Omelchenko", Scores = new int[] { 98, 92, 81, 60 }
                    });
            arrList.Add(
                new Student
                    {
                        FirstName = "Claire", LastName = "O’Donnell", Scores = new int[] { 75, 84, 91, 39 }
                    });
            arrList.Add(
                new Student
                    {
                        FirstName = "Sven", LastName = "Mortensen", Scores = new int[] { 88, 94, 65, 91 }
                    });
            arrList.Add(
                new Student
                    {
                        FirstName = "Cesar", LastName = "Garcia", Scores = new int[] { 97, 89, 85, 82 }
                    });

            var query = from Student student in arrList
                        where student.Scores[0] > 95
                        select student;

            foreach (Student s in query)
                Console.WriteLine(s.LastName + ": " + s.Scores[0]);

            // Keep the console window open in debug mode.
            Console.WriteLine("Press any key to exit.");
            Console.ReadKey();
        }
    }
}
/* Output:
    Omelchenko: 98
    Garcia: 97
*/
```

See also

- LINQ to Objects (C#)

How to: Add Custom Methods for LINQ Queries (C#)

1/23/2019 • 5 minutes to read • Edit Online

You can extend the set of methods that you can use for LINQ queries by adding extension methods to the IEnumerable<T> interface. For example, in addition to the standard average or maximum operations, you can create a custom aggregate method to compute a single value from a sequence of values. You can also create a method that works as a custom filter or a specific data transform for a sequence of values and returns a new sequence. Examples of such methods are Distinct, Skip, and Reverse.

When you extend the IEnumerable<T> interface, you can apply your custom methods to any enumerable collection. For more information, see Extension Methods.

Adding an Aggregate Method

An aggregate method computes a single value from a set of values. LINQ provides several aggregate methods, including Average, Min, and Max. You can create your own aggregate method by adding an extension method to the IEnumerable<T> interface.

The following code example shows how to create an extension method called `Median` to compute a median for a sequence of numbers of type `double`.

```
public static class LINQExtension
{
    public static double Median(this IEnumerable<double> source)
    {
        if (source.Count() == 0)
        {
            throw new InvalidOperationException("Cannot compute median for an empty set.");
        }

        var sortedList = from number in source
                         orderby number
                         select number;

        int itemIndex = (int)sortedList.Count() / 2;

        if (sortedList.Count() % 2 == 0)
        {
            // Even number of items.
            return (sortedList.ElementAt(itemIndex) + sortedList.ElementAt(itemIndex - 1)) / 2;
        }
        else
        {
            // Odd number of items.
            return sortedList.ElementAt(itemIndex);
        }
    }
}
```

You call this extension method for any enumerable collection in the same way you call other aggregate methods from the IEnumerable<T> interface.

The following code example shows how to use the `Median` method for an array of type `double`.

```
double[] numbers1 = { 1.9, 2, 8, 4, 5.7, 6, 7.2, 0 };

var query1 = numbers1.Median();

Console.WriteLine("double: Median = " + query1);
```

```
/*
 This code produces the following output:

 Double: Median = 4.85
*/
```

Overloading an Aggregate Method to Accept Various Types

You can overload your aggregate method so that it accepts sequences of various types. The standard approach is to create an overload for each type. Another approach is to create an overload that will take a generic type and convert it to a specific type by using a delegate. You can also combine both approaches.

To create an overload for each type

You can create a specific overload for each type that you want to support. The following code example shows an overload of the `Median` method for the `integer` type.

```
//int overload

public static double Median(this IEnumerable<int> source)
{
    return (from num in source select (double)num).Median();
}
```

You can now call the `Median` overloads for both `integer` and `double` types, as shown in the following code:

```
double[] numbers1 = { 1.9, 2, 8, 4, 5.7, 6, 7.2, 0 };

var query1 = numbers1.Median();

Console.WriteLine("double: Median = " + query1);
```

```
int[] numbers2 = { 1, 2, 3, 4, 5 };

var query2 = numbers2.Median();

Console.WriteLine("int: Median = " + query2);
```

```
/*
 This code produces the following output:

 Double: Median = 4.85
 Integer: Median = 3
*/
```

To create a generic overload

You can also create an overload that accepts a sequence of generic objects. This overload takes a delegate as a parameter and uses it to convert a sequence of objects of a generic type to a specific type.

The following code shows an overload of the `Median` method that takes the Func<T,TResult> delegate as a parameter. This delegate takes an object of generic type T and returns an object of type `double`.

```
// Generic overload.

public static double Median<T>(this IEnumerable<T> numbers,
                       Func<T, double> selector)
{
    return (from num in numbers select selector(num)).Median();
}
```

You can now call the `Median` method for a sequence of objects of any type. If the type does not have its own method overload, you have to pass a delegate parameter. In C#, you can use a lambda expression for this purpose. Also, in Visual Basic only, if you use the `Aggregate` or `Group By` clause instead of the method call, you can pass any value or expression that is in the scope this clause.

The following example code shows how to call the `Median` method for an array of integers and an array of strings. For strings, the median for the lengths of strings in the array is calculated. The example shows how to pass the Func<T,TResult> delegate parameter to the `Median` method for each case.

```
int[] numbers3 = { 1, 2, 3, 4, 5 };

/*
  You can use the num=>num lambda expression as a parameter for the Median method
  so that the compiler will implicitly convert its value to double.
  If there is no implicit conversion, the compiler will display an error message.
*/

var query3 = numbers3.Median(num => num);

Console.WriteLine("int: Median = " + query3);

string[] numbers4 = { "one", "two", "three", "four", "five" };

// With the generic overload, you can also use numeric properties of objects.

var query4 = numbers4.Median(str => str.Length);

Console.WriteLine("String: Median = " + query4);

/*
 This code produces the following output:

 Integer: Median = 3
 String: Median = 4
*/
```

Adding a Method That Returns a Collection

You can extend the IEnumerable<T> interface with a custom query method that returns a sequence of values. In this case, the method must return a collection of type IEnumerable<T>. Such methods can be used to apply filters or data transforms to a sequence of values.

The following example shows how to create an extension method named `AlternateElements` that returns every other element in a collection, starting from the first element.

```
// Extension method for the IEnumerable<T> interface.
// The method returns every other element of a sequence.

public static IEnumerable<T> AlternateElements<T>(this IEnumerable<T> source)
{
    List<T> list = new List<T>();

    int i = 0;

    foreach (var element in source)
    {
        if (i % 2 == 0)
        {
            list.Add(element);
        }

        i++;
    }

    return list;
}
```

You can call this extension method for any enumerable collection just as you would call other methods from the IEnumerable<T> interface, as shown in the following code:

```
string[] strings = { "a", "b", "c", "d", "e" };

var query = strings.AlternateElements();

foreach (var element in query)
{
    Console.WriteLine(element);
}
/*
 This code produces the following output:

 a
 c
 e
*/
```

See also

- IEnumerable<T>
- Extension Methods

LINQ to XML (C#)

1/23/2019 • 2 minutes to read • Edit Online

LINQ to XML provides an in-memory XML programming interface that leverages the .NET Language-Integrated Query (LINQ) Framework. LINQ to XML uses the latest .NET Framework language capabilities and is comparable to an updated, redesigned Document Object Model (DOM) XML programming interface.

The LINQ family of technologies provides a consistent query experience for objects (LINQ to Objects), relational databases (LINQ to SQL), and XML (LINQ to XML).

In this Section

Getting Started (LINQ to XML)
Provides introductory information about LINQ to XML, including a conceptual overview and an overview of the System.Xml.Linq classes.

Programming Guide (LINQ to XML) (C#)
Provides conceptual and how-to information about programming with LINQ to XML.

Reference (LINQ to XML)
Provides pointers to the LINQ to XML managed reference documentation.

See also

- Language-Integrated Query (LINQ) (C#)

Getting Started (LINQ to XML)

1/23/2019 • 2 minutes to read • Edit Online

The following topics introduce LINQ to XML.

In This Section

TOPIC	DESCRIPTION
LINQ to XML Overview (C#)	Provides an overview of the LINQ to XML technology.
LINQ to XML vs. DOM (C#)	Compares LINQ to XML to the Document Object Model (DOM).
LINQ to XML vs. Other XML Technologies	Compares LINQ to XML to other XML parsing and manipulation technologies: XmlReader, XSLT, MSXML, and XmlLite.

See also

- Reference (LINQ to XML)
- LINQ to XML (C#)

LINQ to XML Overview (C#)

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XML has been widely adopted as a way to format data in many contexts. For example, you can find XML on the Web, in configuration files, in Microsoft Office Word files, and in databases.

LINQ to XML is an up-to-date, redesigned approach to programming with XML. It provides the in-memory document modification capabilities of the Document Object Model (DOM), and supports LINQ query expressions. Although these query expressions are syntactically different from XPath, they provide similar functionality.

LINQ to XML Developers

LINQ to XML targets a variety of developers. For an average developer who just wants to get something done, LINQ to XML makes XML easier by providing a query experience that is similar to SQL. With just a bit of study, programmers can learn to write succinct and powerful queries in their programming language of choice.

Professional developers can use LINQ to XML to greatly increase their productivity. With LINQ to XML, they can write less code that is more expressive, more compact, and more powerful. They can use query expressions from multiple data domains at the same time.

What Is LINQ to XML?

LINQ to XML is a LINQ-enabled, in-memory XML programming interface that enables you to work with XML from within the .NET Framework programming languages.

LINQ to XML is like the Document Object Model (DOM) in that it brings the XML document into memory. You can query and modify the document, and after you modify it you can save it to a file or serialize it and send it over the Internet. However, LINQ to XML differs from DOM: It provides a new object model that is lighter weight and easier to work with, and that takes advantage of language features in C#.

The most important advantage of LINQ to XML is its integration with Language-Integrated Query (LINQ). This integration enables you to write queries on the in-memory XML document to retrieve collections of elements and attributes. The query capability of LINQ to XML is comparable in functionality (although not in syntax) to XPath and XQuery. The integration of LINQ in C# provides stronger typing, compile-time checking, and improved debugger support.

Another advantage of LINQ to XML is the ability to use query results as parameters to XElement and XAttribute object constructors enables a powerful approach to creating XML trees. This approach, called *functional construction*, enables developers to easily transform XML trees from one shape to another.

For example, you might have a typical XML purchase order as described in Sample XML File: Typical Purchase Order (LINQ to XML). By using LINQ to XML, you could run the following query to obtain the part number attribute value for every item element in the purchase order:

```
// Load the XML file from our project directory containing the purchase orders
var filename = "PurchaseOrder.xml";
var currentDirectory = Directory.GetCurrentDirectory();
var purchaseOrderFilepath = Path.Combine(currentDirectory, filename);

XElement purchaseOrder = XElement.Load($"{purchaseOrderFilepath}");

IEnumerable<string> partNos =  from item in purchaseOrder.Descendants("Item")
                               select (string) item.Attribute("PartNumber");
```

This can be rewritten in method syntax form:

```
IEnumerable<string> partNos = purchaseOrder.Descendants("Item").Select(x => (string)
x.Attribute("PartNumber"));
```

As another example, you might want a list, sorted by part number, of the items with a value greater than $100. To obtain this information, you could run the following query:

```
// Load the XML file from our project directory containing the purchase orders
var filename = "PurchaseOrder.xml";
var currentDirectory = Directory.GetCurrentDirectory();
var purchaseOrderFilepath = Path.Combine(currentDirectory, filename);

XElement purchaseOrder = XElement.Load($"{purchaseOrderFilepath}");

IEnumerable<XElement> pricesByPartNos =  from item in purchaseOrder.Descendants("Item")
                                 where (int) item.Element("Quantity") * (decimal) item.Element("USPrice") >
100
                                 orderby (string)item.Element("PartNumber")
                                 select item;
```

Again, this can be rewritten in method syntax form:

```
IEnumerable<XElement> pricesByPartNos = purchaseOrder.Descendants("Item")
                                        .Where(item => (int)item.Element("Quantity") *
(decimal)item.Element("USPrice") > 100)
                                        .OrderBy(order => order.Element("PartNumber"));
```

In addition to these LINQ capabilities, LINQ to XML provides an improved XML programming interface. Using LINQ to XML, you can:

- Load XML from files or streams.
- Serialize XML to files or streams.
- Create XML from scratch by using functional construction.
- Query XML using XPath-like axes.
- Manipulate the in-memory XML tree by using methods such as Add, Remove, ReplaceWith, and SetValue.
- Validate XML trees using XSD.
- Use a combination of these features to transform XML trees from one shape into another.

Creating XML Trees

One of the most significant advantages of programming with LINQ to XML is that it is easy to create XML trees.

For example, to create a small XML tree, you can write code as follows:

```
XElement contacts =
new XElement("Contacts",
    new XElement("Contact",
        new XElement("Name", "Patrick Hines"),
        new XElement("Phone", "206-555-0144",
            new XAttribute("Type", "Home")),
        new XElement("phone", "425-555-0145",
            new XAttribute("Type", "Work")),
        new XElement("Address",
            new XElement("Street1", "123 Main St"),
            new XElement("City", "Mercer Island"),
            new XElement("State", "WA"),
            new XElement("Postal", "68042")
        )
    )
);
```

For more information, see Creating XML Trees (C#).

See also

- System.Xml.Linq
- Getting Started (LINQ to XML)

LINQ to XML vs. DOM (C#)

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This section describes some key differences between LINQ to XML and the current predominant XML programming API, the W3C Document Object Model (DOM).

New Ways to Construct XML Trees

In the W3C DOM, you build an XML tree from the bottom up; that is, you create a document, you create elements, and then you add the elements to the document.

For example, the following would be a typical way to create an XML tree using the Microsoft implementation of DOM, XmlDocument:

```
XmlDocument doc = new XmlDocument();
XmlElement name = doc.CreateElement("Name");
name.InnerText = "Patrick Hines";
XmlElement phone1 = doc.CreateElement("Phone");
phone1.SetAttribute("Type", "Home");
phone1.InnerText = "206-555-0144";
XmlElement phone2 = doc.CreateElement("Phone");
phone2.SetAttribute("Type", "Work");
phone2.InnerText = "425-555-0145";
XmlElement street1 = doc.CreateElement("Street1");
street1.InnerText = "123 Main St";
XmlElement city = doc.CreateElement("City");
city.InnerText = "Mercer Island";
XmlElement state = doc.CreateElement("State");
state.InnerText = "WA";
XmlElement postal = doc.CreateElement("Postal");
postal.InnerText = "68042";
XmlElement address = doc.CreateElement("Address");
address.AppendChild(street1);
address.AppendChild(city);
address.AppendChild(state);
address.AppendChild(postal);
XmlElement contact = doc.CreateElement("Contact");
contact.AppendChild(name);
contact.AppendChild(phone1);
contact.AppendChild(phone2);
contact.AppendChild(address);
XmlElement contacts = doc.CreateElement("Contacts");
contacts.AppendChild(contact);
doc.AppendChild(contacts);
```

This style of coding does not visually provide much information about the structure of the XML tree. LINQ to XML supports this approach to constructing an XML tree, but also supports an alternative approach, *functional construction*. Functional construction uses the XElement and XAttribute constructors to build an XML tree.

Here is how you would construct the same XML tree by using LINQ to XML functional construction:

```
XElement contacts =
    new XElement("Contacts",
        new XElement("Contact",
            new XElement("Name", "Patrick Hines"),
            new XElement("Phone", "206-555-0144",
                new XAttribute("Type", "Home")),
            new XElement("phone", "425-555-0145",
                new XAttribute("Type", "Work")),
            new XElement("Address",
                new XElement("Street1", "123 Main St"),
                new XElement("City", "Mercer Island"),
                new XElement("State", "WA"),
                new XElement("Postal", "68042")
            )
        )
    );
```

Notice that indenting the code to construct the XML tree shows the structure of the underlying XML.

For more information, see Creating XML Trees (C#).

Working Directly with XML Elements

When you program with XML, your primary focus is usually on XML elements and perhaps on attributes. In LINQ to XML, you can work directly with XML elements and attributes. For example, you can do the following:

- Create XML elements without using a document object at all. This simplifies programming when you have to work with fragments of XML trees.
- Load `T:System.Xml.Linq.XElement` objects directly from an XML file.
- Serialize `T:System.Xml.Linq.XElement` objects to a file or a stream.

Compare this to the W3C DOM, in which the XML document is used as a logical container for the XML tree. In DOM, XML nodes, including elements and attributes, must be created in the context of an XML document. Here is a fragment of the code to create a name element in DOM:

```
XmlDocument doc = new XmlDocument();
XmlElement name = doc.CreateElement("Name");
name.InnerText = "Patrick Hines";
doc.AppendChild(name);
```

If you want to use an element across multiple documents, you must import the nodes across documents. LINQ to XML avoids this layer of complexity.

When using LINQ to XML, you use the XDocument class only if you want to add a comment or processing instruction at the root level of the document.

Simplified Handling of Names and Namespaces

Handling names, namespaces, and namespace prefixes is generally a complex part of XML programming. LINQ to XML simplifies names and namespaces by eliminating the requirement to deal with namespace prefixes. If you want to control namespace prefixes, you can. But if you decide to not explicitly control namespace prefixes, LINQ to XML will assign namespace prefixes during serialization if they are required, or will serialize using default namespaces if they are not. If default namespaces are used, there will be no namespace prefixes in the resulting document. For more information, see Working with XML Namespaces (C#).

Another problem with the DOM is that it does not let you change the name of a node. Instead, you have to create a new node and copy all the child nodes to it, losing the original node identity. LINQ to XML avoids this problem by enabling you to set the XName property on a node.

Static Method Support for Loading XML

LINQ to XML lets you load XML by using static methods, instead of instance methods. This simplifies loading and parsing. For more information, see How to: Load XML from a File (C#).

Removal of Support for DTD Constructs

LINQ to XML further simplifies XML programming by removing support for entities and entity references. The management of entities is complex, and is rarely used. Removing their support increases performance and simplifies the programming interface. When a LINQ to XML tree is populated, all DTD entities are expanded.

Support for Fragments

LINQ to XML does not provide an equivalent for the `XmlDocumentFragment` class. In many cases, however, the `XmlDocumentFragment` concept can be handled by the result of a query that is typed as IEnumerable<T> of XNode, or IEnumerable<T> of XElement.

Support for XPathNavigator

LINQ to XML provides support for XPathNavigator through extension methods in the System.Xml.XPath namespace. For more information, see System.Xml.XPath.Extensions.

Support for White Space and Indentation

LINQ to XML handles white space more simply than the DOM.

A common scenario is to read indented XML, create an in-memory XML tree without any white space text nodes (that is, not preserving white space), perform some operations on the XML, and then save the XML with indentation. When you serialize the XML with formatting, only significant white space in the XML tree is preserved. This is the default behavior for LINQ to XML.

Another common scenario is to read and modify XML that has already been intentionally indented. You might not want to change this indentation in any way. In LINQ to XML, you can do this by preserving white space when you load or parse the XML and disabling formatting when you serialize the XML.

LINQ to XML stores white space as an XText node, instead of having a specialized Whitespace node type, as the DOM does.

Support for Annotations

LINQ to XML elements support an extensible set of annotations. This is useful for tracking miscellaneous information about an element, such as schema information, information about whether the element is bound to a UI, or any other kind of application-specific information. For more information, see LINQ to XML Annotations.

Support for Schema Information

LINQ to XML provides support for XSD validation through extension methods in the System.Xml.Schema namespace. You can validate that an XML tree complies with an XSD. You can populate the XML tree with the post-schema-validation infoset (PSVI). For more information, see How to: Validate Using XSD and Extensions.

See also

- Getting Started (LINQ to XML)

LINQ to XML vs. Other XML Technologies

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This topic compares LINQ to XML to the following XML technologies: XmlReader, XSLT, MSXML, and XmlLite. This information can help you decide which technology to use.

For a comparison of LINQ to XML to the Document Object Model (DOM), see LINQ to XML vs. DOM (C#).

LINQ to XML vs. XmlReader

XmlReader is a fast, forward-only, non-caching parser.

LINQ to XML is implemented on top of XmlReader, and they are tightly integrated. However, you can also use XmlReader by itself.

For example, suppose you are building a Web service that will parse hundreds of XML documents per second, and the documents have the same structure, meaning that you only have to write one implementation of the code to parse the XML. In this case, you would probably want to use XmlReader by itself.

In contrast, if you are building a system that parses many smaller XML documents, and each one is different, you would want to take advantage of the productivity improvements that LINQ to XML provides.

LINQ to XML vs. XSLT

Both LINQ to XML and XSLT provide extensive XML document transformation capabilities. XSLT is a rule-based, declarative approach. Advanced XSLT programmers write XSLT in a functional programming style that emphasizes a stateless approach. Transformations can be written using pure functions that are implemented without side effects. This rule-based or functional approach is unfamiliar to many developers, and can be difficult and time-consuming to learn.

XSLT can be a very productive system that yields high-performance applications. For example, some big Web companies use XSLT as a way to generate HTML from XML that has been pulled from a variety of data stores. The managed XSLT engine compiles XSLT to CLR code, and performs even better in some scenarios than the native XSLT engine.

However, XSLT does not take advantage of the C# and Visual Basic knowledge that many developers have. It requires developers to write code in a different and complex programming language. Using two non-integrated development systems such as C# (or Visual Basic) and XSLT results in software systems that are more difficult to develop and maintain.

After you have mastered LINQ to XML query expressions, LINQ to XML transformations are a powerful technology that is easy to use. Basically, you form your XML document by using functional construction, pulling in data from various sources, constructing XElement objects dynamically, and assembling the whole into a new XML tree. The transformation can generate a completely new document. Constructing transformations in LINQ to XML is relatively easy and intuitive, and the resulting code is readable. This reduces development and maintenance costs.

LINQ to XML is not intended to replace XSLT. XSLT is still the tool of choice for complicated and document-centric XML transformations, especially if the structure of the document is not well defined.

XSLT has the advantage of being a World Wide Web Consortium (W3C) standard. If you have a requirement that you use only technologies that are standards, XSLT might be more appropriate.

XSLT is XML, and therefore can be programmatically manipulated.

LINQ to XML vs. MSXML

MSXML is the COM-based technology for processing XML that is included with Microsoft Windows. MSXML provides a native implementation of the DOM with support for XPath and XSLT. It also contains the SAX2 non-caching, event-based parser.

MSXML performs well, is secure by default in most scenarios, and can be accessed in Internet Explorer for performing client-side XML processing in AJAX-style applications. MSXML can be used from any programming language that supports COM, including C++, JavaScript, and Visual Basic 6.0.

MSXML is not recommended for use in managed code based on the common language runtime (CLR).

LINQ to XML vs. XmlLite

XmlLite is a non-caching, forward only, pull parser. Developers primarily use XmlLite with C++. It is not recommended for developers to use XmlLite with managed code.

The main advantage of XmlLite is that it is a lightweight, fast XML parser that is secure in most scenarios. Its threat surface area is very small. If you have to parse untrusted documents and you want to protect against attacks such as denial of service or exposure of data, XmlLite might be a good option.

XmlLite is not integrated with Language-Integrated Query (LINQ). It does not yield the programmer productivity improvements that are the motivating force behind LINQ.

See also

- Getting Started (LINQ to XML)

Programming Guide (LINQ to XML) (C#)

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This section provides conceptual and how-to information about programming with LINQ to XML.

Who Should Read This Documentation

This documentation targets developers who already understand C# and some basic aspects of the .NET Framework.

The goal of this documentation is to make LINQ to XML easy to use for all kinds of developers. LINQ to XML makes XML programming easier. You do not have to be an expert developer to use it.

LINQ to XML relies heavily on generic classes. Therefore, is very important that you understand the use of generic classes. Further, it is helpful if you are familiar with delegates that are declared as parameterized types. If you are not familiar with C# generic classes, see Generic Classes.

In This Section

TOPIC	DESCRIPTION
LINQ to XML Programming Overview (C#)	Provides an overview of the LINQ to XML classes, and detailed information about three of the most important classes: XElement, XAttribute, and XDocument.
Creating XML Trees (C#)	Provides conceptual and task-based information about creating XML trees. You can create XML trees by using functional construction, or by parsing XML text from a string or a file. You can also use an XmlReader to populate an XML tree.
Working with XML Namespaces (C#)	Provides detailed information about creating XML trees that use namespaces.
Serializing XML Trees (C#)	Describes multiple approaches to serializing an XML tree, and gives guidance on which approach to use.
LINQ to XML Axes (C#)	Enumerates and describes the LINQ to XML axis methods, which you must understand before you can write LINQ to XML queries.
Querying XML Trees (C#)	Provides common examples of querying XML trees.
Modifying XML Trees (LINQ to XML) (C#)	Like the Document Object Model (DOM), LINQ to XML enables you to modify an XML tree in place.
Advanced LINQ to XML Programming (C#)	Provides information about annotations, events, streaming, and other advanced scenarios.
LINQ to XML Security (C#)	Describes security issues associated with LINQ to XML and provides some guidance for mitigating security exposure.

TOPIC	DESCRIPTION
Sample XML Documents (LINQ to XML)	Contains the sample XML documents that are used by many examples in this documentation.

See also

- Getting Started (LINQ to XML)
- LINQ to XML (C#)

LINQ to XML Programming Overview (C#)

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These topics provide high-level overview information about the LINQ to XML classes, as well as detailed information about three of the most important classes.

In This Section

TOPIC	DESCRIPTION
Functional vs. Procedural Programming (LINQ to XML) (C#)	Provides a high level view of the two principle approaches to writing LINQ to XML applications.
LINQ to XML Classes Overview (C#)	Provides an overview of the LINQ to XML classes.
XElement Class Overview (C#)	Introduces the XElement class, which represents XML elements. XElement is one of the fundamental classes in the LINQ to XML class hierarchy.
XAttribute Class Overview (C#)	Introduces the XAttribute class, which represents XML attributes.
XDocument Class Overview (C#)	Introduces the XDocument class, which represents XML documents.
How to: Build LINQ to XML Examples (C#)	Contains the `Using` directives that are required to build the LINQ to XML examples.

See also

- Programming Guide (LINQ to XML) (C#)

Functional vs. Procedural Programming (LINQ to XML) (C#)

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There are various types of XML applications:

- Some applications take source XML documents, and produce new XML documents that are in a different shape than the source documents.
- Some applications take source XML documents, and produce result documents in an entirely different form, such as HTML or CSV text files.
- Some applications take source XML documents, and insert records into a database.
- Some applications take data from another source, such as a database, and create XML documents from it.

These are not all of the types of XML applications, but these are a representative set of the types of functionality that an XML programmer has to implement.

With all of these types of applications, there are two contrasting approaches that a developer can take:

- Functional construction using a declarative approach.
- In-memory XML tree modification using procedural code.

LINQ to XML supports both approaches.

When using the functional approach, you write transformations that take the source documents and generate completely new result documents with the desired shape.

When modifying an XML tree in place, you write code that traverses and navigates through nodes in an in-memory XML tree, inserting, deleting, and modifying nodes as necessary.

You can use LINQ to XML with either approach. You use the same classes, and in some cases the same methods. However, the structure and goals of the two approaches are very different. For example, in different situations, one or the other approach will often have better performance, and use more or less memory. In addition, one or the other approach will be easier to write and yield more maintainable code.

To see the two approaches contrasted, see In-Memory XML Tree Modification vs. Functional Construction (LINQ to XML) (C#).

For a tutorial on writing functional transformations, see Pure Functional Transformations of XML (C#).

See also

- LINQ to XML Programming Overview (C#)

LINQ to XML Classes Overview (C#)

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This topic provides a list of the LINQ to XML classes in the System.Xml.Linq namespace, and a short description of each.

LINQ to XML Classes

XAttribute Class

XAttribute represents an XML attribute. For detailed information and examples, see XAttribute Class Overview (C#).

XCData Class

XCData represents a CDATA text node.

XComment Class

XComment represents an XML comment.

XContainer Class

XContainer is an abstract base class for all nodes that can have child nodes. The following classes derive from the XContainer class:

- XElement
- XDocument

XDeclaration Class

XDeclaration represents an XML declaration. An XML declaration is used to declare the XML version and the encoding of a document. In addition, an XML declaration specifies whether the XML document is stand-alone. If a document is stand-alone, there are no external markup declarations, either in an external DTD, or in an external parameter entity referenced from the internal subset.

XDocument Class

XDocument represents an XML document. For detailed information and examples, see XDocument Class Overview (C#).

XDocumentType Class

XDocumentType represents an XML Document Type Definition (DTD).

XElement Class

XElement represents an XML element. For detailed information and examples, see XElement Class Overview (C#).

XName Class

XName represents names of elements (XElement) and attributes (XAttribute). For detailed information and examples, see XDocument Class Overview (C#).

LINQ to XML is designed to make XML names as straightforward as possible. Due to their complexity, XML names are often considered to be an advanced topic in XML. Arguably, this complexity comes not from namespaces, which developers use regularly in programming, but from namespace prefixes. Namespace prefixes can be useful to reduce the keystrokes required when you input XML, or to make XML easier to read. However, prefixes are often just a shortcut for using the full XML namespace, and are not required in most cases. LINQ to XML simplifies XML names by resolving all prefixes to their corresponding XML namespace. Prefixes are available, if they are required, through the GetPrefixOfNamespace method.

It is possible, if necessary, to control namespace prefixes. In some circumstances, if you are working with other XML systems, such as XSLT or XAML, you need to control namespace prefixes. For example, if you have an XPath expression that uses namespace prefixes and is embedded in an XSLT stylesheet, you must make sure that your XML document is serialized with namespace prefixes that match those used in the XPath expression.

XNamespace Class

XNamespace represents a namespace for an XElement or XAttribute. Namespaces are a component of an XName.

XNode Class

XNode is an abstract class that represents the nodes of an XML tree. The following classes derive from the XNode class:

- XText
- XContainer
- XComment
- XProcessingInstruction
- XDocumentType

XNodeDocumentOrderComparer Class

XNodeDocumentOrderComparer provides functionality to compare nodes for their document order.

XNodeEqualityComparer Class

XNodeEqualityComparer provides functionality to compare nodes for value equality.

XObject Class

XObject is an abstract base class of XNode and XAttribute. It provides annotation and event functionality.

XObjectChange Class

XObjectChange specifies the event type when an event is raised for an XObject.

XObjectChangeEventArgs Class

XObjectChangeEventArgs provides data for the Changing and Changed events.

XProcessingInstruction Class

XProcessingInstruction represents an XML processing instruction. A processing instruction communicates information to an application that processes the XML.

XText Class

XText represents a text node. In most cases, you do not have to use this class. This class is primarily used for mixed content.

See also

- LINQ to XML Programming Overview (C#)

XElement Class Overview (C#)

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The XElement class is one of the fundamental classes in LINQ to XML. It represents an XML element. You can use this class to create elements; change the content of the element; add, change, or delete child elements; add attributes to an element; or serialize the contents of an element in text form. You can also interoperate with other classes in System.Xml, such as XmlReader, XmlWriter, and XslCompiledTransform.

XElement Functionality

This topic describes the functionality provided by the XElement class.

Constructing XML Trees

You can construct XML trees in a variety of ways, including the following:

- You can construct an XML tree in code. For more information, see Creating XML Trees (C#).
- You can parse XML from various sources, including a TextReader, text files, or a Web address (URL). For more information, see Parsing XML (C#).
- You can use an XmlReader to populate the tree. For more information, see ReadFrom.
- If you have a module that can write content to an XmlWriter, you can use the CreateWriter method to create a writer, pass the writer to the module, and then use the content that is written to the XmlWriter to populate the XML tree.

However, the most common way to create an XML tree is as follows:

```
XElement contacts =
    new XElement("Contacts",
        new XElement("Contact",
            new XElement("Name", "Patrick Hines"),
            new XElement("Phone", "206-555-0144"),
            new XElement("Address",
                new XElement("Street1", "123 Main St"),
                new XElement("City", "Mercer Island"),
                new XElement("State", "WA"),
                new XElement("Postal", "68042")
            )
        )
    );
```

Another very common technique for creating an XML tree involves using the results of a LINQ query to populate an XML tree, as shown in the following example:

```
XElement srcTree = new XElement("Root",
    new XElement("Element", 1),
    new XElement("Element", 2),
    new XElement("Element", 3),
    new XElement("Element", 4),
    new XElement("Element", 5)
);
XElement xmlTree = new XElement("Root",
    new XElement("Child", 1),
    new XElement("Child", 2),
    from el in srcTree.Elements()
    where (int)el > 2
    select el
);
Console.WriteLine(xmlTree);
```

This example produces the following output:

```
<Root>
  <Child>1</Child>
  <Child>2</Child>
  <Element>3</Element>
  <Element>4</Element>
  <Element>5</Element>
</Root>
```

Serializing XML Trees

You can serialize the XML tree to a File, a TextWriter, or an XmlWriter.

For more information, see Serializing XML Trees (C#).

Retrieving XML Data via Axis Methods

You can use axis methods to retrieve attributes, child elements, descendant elements, and ancestor elements. LINQ queries operate on axis methods, and provide several flexible and powerful ways to navigate through and process an XML tree.

For more information, see LINQ to XML Axes (C#).

Querying XML Trees

You can write LINQ queries that extract data from an XML tree.

For more information, see Querying XML Trees (C#).

Modifying XML Trees

You can modify an element in a variety of ways, including changing its content or attributes. You can also remove an element from its parent.

For more information, see Modifying XML Trees (LINQ to XML) (C#).

See also

- LINQ to XML Programming Overview (C#)

XAttribute Class Overview (C#)

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Attributes are name/value pairs that are associated with an element. The XAttribute class represents XML attributes.

Overview

Working with attributes in LINQ to XML is similar to working with elements. Their constructors are similar. The methods that you use to retrieve collections of them are similar. A LINQ query expression for a collection of attributes looks very similar to a LINQ query expression for a collection of elements.

The order in which attributes were added to an element is preserved. That is, when you iterate through the attributes, you see them in the same order that they were added.

The XAttribute Constructor

The following constructor of the XAttribute class is the one that you will most commonly use:

CONSTRUCTOR	DESCRIPTION
`XAttribute(XName name, object content)`	Creates an XAttribute object. The `name` argument specifies the name of the attribute; `content` specifies the content of the attribute.

Creating an Element with an Attribute

The following code shows the common task of creating an element that contains an attribute:

```
XElement phone = new XElement("Phone",
    new XAttribute("Type", "Home"),
    "555-555-5555");
Console.WriteLine(phone);
```

This example produces the following output:

```
<Phone Type="Home">555-555-5555</Phone>
```

Functional Construction of Attributes

You can construct XAttribute objects in-line with the construction of XElement objects, as follows:

```
XElement c = new XElement("Customers",
    new XElement("Customer",
        new XElement("Name", "John Doe"),
        new XElement("PhoneNumbers",
            new XElement("Phone",
                new XAttribute("type", "home"),
                "555-555-5555"),
            new XElement("Phone",
                new XAttribute("type", "work"),
                "666-666-6666")
        )
    )
);
Console.WriteLine(c);
```

This example produces the following output:

```
<Customers>
  <Customer>
    <Name>John Doe</Name>
    <PhoneNumbers>
      <Phone type="home">555-555-5555</Phone>
      <Phone type="work">666-666-6666</Phone>
    </PhoneNumbers>
  </Customer>
</Customers>
```

Attributes Are Not Nodes

There are some differences between attributes and elements. XAttribute objects are not nodes in the XML tree. They are name/value pairs associated with an XML element. In contrast to the Document Object Model (DOM), this more closely reflects the structure of XML. Although XAttribute objects are not actually nodes in the XML tree, working with XAttribute objects is very similar to working with XElement objects.

This distinction is primarily important only to developers who are writing code that works with XML trees at the node level. Many developers will not be concerned with this distinction.

See also

- LINQ to XML Programming Overview (C#)

XDocument Class Overview (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic introduces the XDocument class.

Overview of the XDocument class

The XDocument class contains the information necessary for a valid XML document. This includes an XML declaration, processing instructions, and comments.

Note that you only have to create XDocument objects if you require the specific functionality provided by the XDocument class. In many circumstances, you can work directly with XElement. Working directly with XElement is a simpler programming model.

XDocument derives from XContainer. Therefore, it can contain child nodes. However, XDocument objects can have only one child XElement node. This reflects the XML standard that there can be only one root element in an XML document.

Components of XDocument

An XDocument can contain the following elements:

- One XDeclaration object. XDeclaration enables you to specify the pertinent parts of an XML declaration: the XML version, the encoding of the document, and whether the XML document is stand-alone.
- One XElement object. This is the root node of the XML document.
- Any number of XProcessingInstruction objects. A processing instruction communicates information to an application that processes the XML.
- Any number of XComment objects. The comments will be siblings to the root element. The XComment object cannot be the first argument in the list, because it is not valid for an XML document to start with a comment.
- One XDocumentType for the DTD.

When you serialize an XDocument, even if `XDocument.Declaration` is `null`, the output will have an XML declaration if the writer has `Writer.Settings.OmitXmlDeclaration` set to `false` (the default).

By default, LINQ to XML sets the version to "1.0", and sets the encoding to "utf-8".

Using XElement without XDocument

As previously mentioned, the XElement class is the main class in the LINQ to XML programming interface. In many cases, your application will not require that you create a document. By using the XElement class, you can create an XML tree, add other XML trees to it, modify the XML tree, and save it.

Using XDocument

To construct an XDocument, use functional construction, just like you do to construct XElement objects.

The following code creates an XDocument object and its associated contained objects.

```
XDocument d = new XDocument(
    new XComment("This is a comment."),
    new XProcessingInstruction("xml-stylesheet",
        "href='mystyle.css' title='Compact' type='text/css'"),
    new XElement("Pubs",
        new XElement("Book",
            new XElement("Title", "Artifacts of Roman Civilization"),
            new XElement("Author", "Moreno, Jordao")
        ),
        new XElement("Book",
            new XElement("Title", "Midieval Tools and Implements"),
            new XElement("Author", "Gazit, Inbar")
        )
    ),
    new XComment("This is another comment.")
);
d.Declaration = new XDeclaration("1.0", "utf-8", "true");
Console.WriteLine(d);

d.Save("test.xml");
```

When you examine the file test.xml, you get the following output:

```
<?xml version="1.0" encoding="utf-8"?>
<!--This is a comment.-->
<?xml-stylesheet href='mystyle.css' title='Compact' type='text/css'?>
<Pubs>
  <Book>
    <Title>Artifacts of Roman Civilization</Title>
    <Author>Moreno, Jordao</Author>
  </Book>
  <Book>
    <Title>Midieval Tools and Implements</Title>
    <Author>Gazit, Inbar</Author>
  </Book>
</Pubs>
<!--This is another comment.-->
```

See also

- LINQ to XML Programming Overview (C#)

How to: Build LINQ to XML Examples (C#)

1/23/2019 • 2 minutes to read • Edit Online

The various snippets and examples in this documentation use classes and types from a variety of namespaces. When compiling C# code, you need to supply appropriate `using` directives.

Example

The following code contains the `using` directives that the C# examples require to build and run. Not all `using` directives are required for every example.

```
using System;
using System.Diagnostics;
using System.Collections;
using System.Collections.Generic;
using System.Collections.Specialized;
using System.Text;
using System.Linq;
using System.Xml;
using System.Xml.Linq;
using System.Xml.Schema;
using System.Xml.XPath;
using System.Xml.Xsl;
using System.IO;
using System.Threading;
using System.Reflection;
using System.IO.Packaging;
```

See also

- LINQ to XML Programming Overview (C#)

Creating XML Trees (C#)

1/23/2019 • 2 minutes to read • Edit Online

One of the most common XML tasks is constructing an XML tree. This section describes several ways to create them.

In This Section

TOPIC	DESCRIPTION
Functional Construction (LINQ to XML) (C#)	Provides an overview of functional construction in LINQ to XML. Functional construction enables you to create all or part of your XML tree in a single statement. This topic also shows how to embed queries when constructing an XML tree.
Creating XML Trees in C# (LINQ to XML)	Shows how to create trees in C#.
Parsing XML (C#)	Shows how to parse XML from a variety of sources. LINQ to XML is layered on top of XmlReader, which is used to parse the XML.
How to: Populate an XML Tree with an XmlWriter (LINQ to XML) (C#)	Shows how to populate an XML tree by using an XmlWriter.
How to: Validate Using XSD (LINQ to XML) (C#)	Shows how to validate an XML tree using XSD.
Valid Content of XElement and XDocument Objects	Describes the valid arguments that can be passed to the constructors and methods that are used to add content to elements and documents.

See also

- Programming Guide (LINQ to XML) (C#)

Functional Construction (LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

LINQ to XML provides a powerful way to create XML elements called *functional construction*. Functional construction is the ability to create an XML tree in a single statement.

There are several key features of the LINQ to XML programming interface that enable functional construction:

- The XElement constructor takes various types of arguments for content. For example, you can pass another XElement object, which becomes a child element. You can pass an XAttribute object, which becomes an attribute of the element. Or you can pass any other type of object, which is converted to a string and becomes the text content of the element.
- The XElement constructor takes a `params` array of type Object, so that you can pass any number of objects to the constructor. This enables you to create an element that has complex content.
- If an object implements IEnumerable<T>, the collection in the object is enumerated, and all items in the collection are added. If the collection contains XElement or XAttribute objects, each item in the collection is added separately. This is important because it lets you pass the results of a LINQ query to the constructor.

These features enable you to write code to create an XML tree. The following is an example:

```
XElement contacts =
    new XElement("Contacts",
        new XElement("Contact",
            new XElement("Name", "Patrick Hines"),
            new XElement("Phone", "206-555-0144"),
            new XElement("Address",
                new XElement("Street1", "123 Main St"),
                new XElement("City", "Mercer Island"),
                new XElement("State", "WA"),
                new XElement("Postal", "68042")
            )
        )
    );
```

These features also enable you to write code that uses the results of LINQ queries when you create an XML tree, as follows:

```
XElement srcTree = new XElement("Root",
    new XElement("Element", 1),
    new XElement("Element", 2),
    new XElement("Element", 3),
    new XElement("Element", 4),
    new XElement("Element", 5)
);
XElement xmlTree = new XElement("Root",
    new XElement("Child", 1),
    new XElement("Child", 2),
    from el in srcTree.Elements()
    where (int)el > 2
    select el
);
Console.WriteLine(xmlTree);
```

This example produces the following output:

```
<Root>
  <Child>1</Child>
  <Child>2</Child>
  <Element>3</Element>
  <Element>4</Element>
  <Element>5</Element>
</Root>
```

See also

- Creating XML Trees (C#)

Creating XML trees in C# (LINQ to XML)

1/23/2019 • 4 minutes to read • Edit Online

This section provides information about creating XML trees in C#.

For information about using the results of LINQ queries as the content for an XElement, see Functional Construction (LINQ to XML) (C#).

Constructing elements

The signatures of the XElement and XAttribute constructors let you pass the contents of the element or attribute as arguments to the constructor. Because one of the constructors takes a variable number of arguments, you can pass any number of child elements. Of course, each of those child elements can contain their own child elements. For any element, you can add any number of attributes.

When adding XNode (including XElement) or XAttribute objects, if the new content has no parent, the objects are simply attached to the XML tree. If the new content already is parented, and is part of another XML tree, the new content is cloned, and the newly cloned content is attached to the XML tree. The last example in this topic demonstrates this.

To create a `contacts` XElement, you could use the following code:

```
XElement contacts =
    new XElement("Contacts",
        new XElement("Contact",
            new XElement("Name", "Patrick Hines"),
            new XElement("Phone", "206-555-0144"),
            new XElement("Address",
                new XElement("Street1", "123 Main St"),
                new XElement("City", "Mercer Island"),
                new XElement("State", "WA"),
                new XElement("Postal", "68042")
            )
        )
    );
```

If indented properly, the code to construct XElement objects closely resembles the structure of the underlying XML.

XElement constructors

The XElement class uses the following constructors for functional construction. Note that there are some other constructors for XElement, but because they are not used for functional construction they are not listed here.

CONSTRUCTOR	DESCRIPTION
`XElement(XName name, object content)`	Creates an XElement. The `name` parameter specifies the name of the element; `content` specifies the content of the element.
`XElement(XName name)`	Creates an XElement with its XName initialized to the specified name.

CONSTRUCTOR	DESCRIPTION
`XElement(XName name, params object[] content)`	Creates an XElement with its XName initialized to the specified name. The attributes and/or child elements are created from the contents of the parameter list.

The `content` parameter is extremely flexible. It supports any type of object that is a valid child of an XElement. The following rules apply to different types of objects passed in this parameter:

- A string is added as text content.
- An XElement is added as a child element.
- An XAttribute is added as an attribute.
- An XProcessingInstruction, XComment, or XText is added as child content.
- An IEnumerable is enumerated, and these rules are applied recursively to the results.
- For any other type, its `ToString` method is called and the result is added as text content.

Creating an XElement with content

You can create an XElement that contains simple content with a single method call. To do this, specify the content as the second parameter, as follows:

```
XElement n = new XElement("Customer", "Adventure Works");
Console.WriteLine(n);
```

This example produces the following output:

```
<Customer>Adventure Works</Customer>
```

You can pass any type of object as the content. For example, the following code creates an element that contains a floating point number as content:

```
XElement n = new XElement("Cost", 324.50);
Console.WriteLine(n);
```

This example produces the following output:

```
<Cost>324.5</Cost>
```

The floating point number is boxed and passed in to the constructor. The boxed number is converted to a string and used as the content of the element.

Creating an XElement with a child element

If you pass an instance of the XElement class for the content argument, the constructor creates an element with a child element:

```
XElement shippingUnit = new XElement("ShippingUnit",
    new XElement("Cost", 324.50)
);
Console.WriteLine(shippingUnit);
```

This example produces the following output:

```
<ShippingUnit>
  <Cost>324.5</Cost>
</ShippingUnit>
```

Creating an XElement with multiple child elements

You can pass in a number of XElement objects for the content. Each of the XElement objects is included as a child element.

```
XElement address = new XElement("Address",
    new XElement("Street1", "123 Main St"),
    new XElement("City", "Mercer Island"),
    new XElement("State", "WA"),
    new XElement("Postal", "68042")
);
Console.WriteLine(address);
```

This example produces the following output:

```
<Address>
  <Street1>123 Main St</Street1>
  <City>Mercer Island</City>
  <State>WA</State>
  <Postal>68042</Postal>
</Address>
```

By extending the above example, you can create an entire XML tree, as follows:

```
XElement contacts =
    new XElement("Contacts",
        new XElement("Contact",
            new XElement("Name", "Patrick Hines"),
            new XElement("Phone", "206-555-0144"),
            new XElement("Address",
                new XElement("Street1", "123 Main St"),
                new XElement("City", "Mercer Island"),
                new XElement("State", "WA"),
                new XElement("Postal", "68042")
            )
        )
    );
Console.WriteLine(contacts);
```

This example produces the following output:

```
<Contacts>
  <Contact>
    <Name>Patrick Hines</Name>
    <Phone>206-555-0144</Phone>
    <Address>
      <Street1>123 Main St</Street1>
      <City>Mercer Island</City>
      <State>WA</State>
      <Postal>68042</Postal>
    </Address>
  </Contact>
</Contacts>
```

Creating an XElement with an XAttribute

If you pass an instance of the XAttribute class for the content argument, the constructor creates an element with an attribute:

```
XElement phone = new XElement("Phone",
    new XAttribute("Type", "Home"),
    "555-555-5555");
Console.WriteLine(phone);
```

This example produces the following output:

```
<Phone Type="Home">555-555-5555</Phone>
```

Creating an empty element

To create an empty XElement, you do not pass any content to the constructor. The following example creates an empty element:

```
XElement n = new XElement("Customer");
Console.WriteLine(n);
```

This example produces the following output:

```
<Customer />
```

Attaching vs. cloning

As mentioned previously, when adding XNode (including XElement) or XAttribute objects, if the new content has no parent, the objects are simply attached to the XML tree. If the new content already is parented and is part of another XML tree, the new content is cloned, and the newly cloned content is attached to the XML tree.

The following example demonstrates the behavior when you add a parented element to a tree, and when you add an element with no parent to a tree.

```
// Create a tree with a child element.
XElement xmlTree1 = new XElement("Root",
    new XElement("Child1", 1)
);

// Create an element that is not parented.
XElement child2 = new XElement("Child2", 2);

// Create a tree and add Child1 and Child2 to it.
XElement xmlTree2 = new XElement("Root",
    xmlTree1.Element("Child1"),
    child2
);

// Compare Child1 identity.
Console.WriteLine("Child1 was {0}",
    xmlTree1.Element("Child1") == xmlTree2.Element("Child1") ?
    "attached" : "cloned");

// Compare Child2 identity.
Console.WriteLine("Child2 was {0}",
    child2 == xmlTree2.Element("Child2") ?
    "attached" : "cloned");

// The example displays the following output:
//    Child1 was cloned
//    Child2 was attached
```

See also

- Creating XML Trees (C#)

Parsing XML (C#)

1/23/2019 • 2 minutes to read • Edit Online

The topics in this section describe how to parse XML documents.

In This Section

TOPIC	DESCRIPTION
How to: Parse a String (C#)	Shows how to parse a string to create an XML tree.
How to: Load XML from a File (C#)	Shows how to load XML from a URI using the Load method.
Preserving White Space while Loading or Parsing XML	Describes how to control the white space behavior of LINQ to XML while loading XML trees.
How to: Catch Parsing Errors (C#)	Shows how to detect badly formed or invalid XML.
How to: Create a Tree from an XmlReader (C#)	Shows how to create an XML tree directly from an XmlReader.
How to: Stream XML Fragments from an XmlReader (C#)	Shows how to stream XML fragments by using an XmlReader. When you have to process arbitrarily large XML files, it might not be feasible to load the whole XML tree into memory. Instead, you can stream XML fragments.

See also

- Creating XML Trees (C#)

How to: Parse a String (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows how to parse a string to create an XML tree in C#.

Example

The following C# code shows how to parse a string.

```
XElement contacts = XElement.Parse(
    @"<Contacts>
        <Contact>
            <Name>Patrick Hines</Name>
            <Phone Type=""home"">206-555-0144</Phone>
            <Phone type=""work"">425-555-0145</Phone>
            <Address>
            <Street1>123 Main St</Street1>
            <City>Mercer Island</City>
            <State>WA</State>
            <Postal>68042</Postal>
            </Address>
            <NetWorth>10</NetWorth>
        </Contact>
        <Contact>
            <Name>Gretchen Rivas</Name>
            <Phone Type=""mobile"">206-555-0163</Phone>
            <Address>
            <Street1>123 Main St</Street1>
            <City>Mercer Island</City>
            <State>WA</State>
            <Postal>68042</Postal>
            </Address>
            <NetWorth>11</NetWorth>
        </Contact>
    </Contacts>");
Console.WriteLine(contacts);
```

See also

- Parsing XML (C#)

How to: Load XML from a File (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows how to load XML from a URI by using the XElement.Load method.

Example

The following example shows how to load an XML document from a file. The following example loads books.xml and outputs the XML tree to the console.

This example uses the following XML document: Sample XML File: Books (LINQ to XML).

```
XElement booksFromFile = XElement.Load(@"books.xml");
Console.WriteLine(booksFromFile);
```

This code produces the following output:

```
<Catalog>
  <Book id="bk101">
    <Author>Garghentini, Davide</Author>
    <Title>XML Developer's Guide</Title>
    <Genre>Computer</Genre>
    <Price>44.95</Price>
    <PublishDate>2000-10-01</PublishDate>
    <Description>An in-depth look at creating applications
      with XML.</Description>
  </Book>
  <Book id="bk102">
    <Author>Garcia, Debra</Author>
    <Title>Midnight Rain</Title>
    <Genre>Fantasy</Genre>
    <Price>5.95</Price>
    <PublishDate>2000-12-16</PublishDate>
    <Description>A former architect battles corporate zombies,
      an evil sorceress, and her own childhood to become queen
      of the world.</Description>
  </Book>
</Catalog>
```

See also

- Parsing XML (C#)

Preserving White Space while Loading or Parsing XML

1/23/2019 • 2 minutes to read • Edit Online

This topic describes how to control the white-space behavior of LINQ to XML.

A common scenario is to read indented XML, create an in-memory XML tree without any white space text nodes (that is, not preserving white space), perform some operations on the XML, and then save the XML with indentation. When you serialize the XML with formatting, only significant white space in the XML tree is preserved. This is the default behavior for LINQ to XML.

Another common scenario is to read and modify XML that has already been intentionally indented. You might not want to change this indentation in any way. To do this in LINQ to XML, you preserve white space when you load or parse the XML and disable formatting when you serialize the XML.

This topic describes the white-space behavior of methods that populate XML trees. For information about controlling white space when you serialize XML trees, see Preserving White Space While Serializing.

Behavior of Methods that Populate XML Trees

The following methods in the XElement and XDocument classes populate an XML tree. You can populate an XML tree from a file, a TextReader, an XmlReader, or a string:

- XElement.Load
- XElement.Parse
- XDocument.Load
- XDocument.Parse

If the method does not take LoadOptions as an argument, the method will not preserve insignificant white space.

In most cases, if the method takes LoadOptions as an argument, you can optionally preserve insignificant white space as text nodes in the XML tree. However, if the method is loading the XML from an XmlReader, then the XmlReader determines whether white space will be preserved or not. Setting PreserveWhitespace will have no effect.

With these methods, if white space is preserved, insignificant white space is inserted into the XML tree as XText nodes. If white space is not preserved, text nodes are not inserted.

You can create an XML tree by using an XmlWriter. Nodes that are written to the XmlWriter are populated in the tree. However, when you build an XML tree using this method, all nodes are preserved, regardless of whether the node is white space or not, or whether the white space is significant or not.

See also

- Parsing XML (C#)

How to: Catch Parsing Errors (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows how to detect badly formed or invalid XML.

LINQ to XML is implemented using XmlReader. If badly formed or invalid XML is passed to LINQ to XML, the underlying XmlReader class will throw an exception. The various methods that parse XML, such as XElement.Parse, do not catch the exception; the exception can then be caught by your application.

Example

The following code tries to parse invalid XML:

```
try {
    XElement contacts = XElement.Parse(
        @"<Contacts>
            <Contact>
                <Name>Jim Wilson</Name>
            </Contact>
          </Contcts>");

    Console.WriteLine(contacts);
}
catch (System.Xml.XmlException e)
{
    Console.WriteLine(e.Message);
}
```

When you run this code, it throws the following exception:

```
The 'Contacts' start tag on line 1 does not match the end tag of 'Contcts'. Line 5, position 13.
```

For information about the exceptions that you can expect the XElement.Parse, XDocument.Parse, XElement.Load, and XDocument.Load methods to throw, see the XmlReader documentation.

See also

- Parsing XML (C#)

How to: Create a Tree from an XmlReader (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows how to create an XML tree directly from an XmlReader. To create an XElement from an XmlReader, you must position the XmlReader on an element node. The XmlReader will skip comments and processing instructions, but if the XmlReader is positioned on a text node, an error will be thrown. To avoid such errors, always position the XmlReader on an element before you create an XML tree from the XmlReader.

Example

This example uses the following XML document: Sample XML File: Books (LINQ to XML).

The following code creates an `T:System.Xml.XmlReader` object, and then reads nodes until it finds the first element node. It then loads the XElement object.

```
XmlReader r = XmlReader.Create("books.xml");
while (r.NodeType != XmlNodeType.Element)
    r.Read();
XElement e = XElement.Load(r);
Console.WriteLine(e);
```

This example produces the following output:

```
<Catalog>
   <Book id="bk101">
      <Author>Garghentini, Davide</Author>
      <Title>XML Developer's Guide</Title>
      <Genre>Computer</Genre>
      <Price>44.95</Price>
      <PublishDate>2000-10-01</PublishDate>
      <Description>An in-depth look at creating applications
      with XML.</Description>
   </Book>
   <Book id="bk102">
      <Author>Garcia, Debra</Author>
      <Title>Midnight Rain</Title>
      <Genre>Fantasy</Genre>
      <Price>5.95</Price>
      <PublishDate>2000-12-16</PublishDate>
      <Description>A former architect battles corporate zombies,
      an evil sorceress, and her own childhood to become queen
      of the world.</Description>
   </Book>
</Catalog>
```

See also

- Parsing XML (C#)

How to: Stream XML Fragments from an XmlReader (C#)

1/23/2019 • 2 minutes to read • Edit Online

When you have to process large XML files, it might not be feasible to load the whole XML tree into memory. This topic shows how to stream fragments using an XmlReader.

One of the most effective ways to use an XmlReader to read XElement objects is to write your own custom axis method. An axis method typically returns a collection such as IEnumerable<T> of XElement, as shown in the example in this topic. In the custom axis method, after you create the XML fragment by calling the ReadFrom method, return the collection using `yield return`. This provides deferred execution semantics to your custom axis method.

When you create an XML tree from an XmlReader object, the XmlReader must be positioned on an element. The ReadFrom method does not return until it has read the close tag of the element.

If you want to create a partial tree, you can instantiate an XmlReader, position the reader on the node that you want to convert to an XElement tree, and then create the XElement object.

The topic How to: Stream XML Fragments with Access to Header Information (C#) contains information and an example on how to stream a more complex document.

The topic How to: Perform Streaming Transform of Large XML Documents (C#) contains an example of using LINQ to XML to transform extremely large XML documents while maintaining a small memory footprint.

Example

This example creates a custom axis method. You can query it by using a LINQ query. The custom axis method, `StreamRootChildDoc`, is a method that is designed specifically to read a document that has a repeating `Child` element.

```
static IEnumerable<XElement> StreamRootChildDoc(StringReader stringReader)
{
    using (XmlReader reader = XmlReader.Create(stringReader))
    {
        reader.MoveToContent();
        // Parse the file and display each of the nodes.
        while (reader.Read())
        {
            switch (reader.NodeType)
            {
                case XmlNodeType.Element:
                    if (reader.Name == "Child") {
                        XElement el = XElement.ReadFrom(reader) as XElement;
                        if (el != null)
                            yield return el;
                    }
                    break;
            }
        }
    }
}

static void Main(string[] args)
{
    string markup = @"<Root>
      <Child Key=""01"">
        <GrandChild>aaa</GrandChild>
      </Child>
      <Child Key=""02"">
        <GrandChild>bbb</GrandChild>
      </Child>
      <Child Key=""03"">
        <GrandChild>ccc</GrandChild>
      </Child>
    </Root>";

    IEnumerable<string> grandChildData =
        from el in StreamRootChildDoc(new StringReader(markup))
        where (int)el.Attribute("Key") > 1
        select (string)el.Element("GrandChild");

    foreach (string str in grandChildData) {
        Console.WriteLine(str);
    }
}
```

This example produces the following output:

```
bbb
ccc
```

In this example, the source document is very small. However, even if there were millions of `Child` elements, this example would still have a small memory footprint.

See also

- Parsing XML (C#)

How to: Populate an XML Tree with an XmlWriter (LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

One way to populate an XML tree is to use CreateWriter to create an XmlWriter, and then write to the XmlWriter. The XML tree is populated with all nodes that are written to the XmlWriter.

You would typically use this method when you use LINQ to XML with another class that expects to write to an XmlWriter, such as XslCompiledTransform.

Example

One possible use for CreateWriter is when invoking an XSLT transformation. This example creates an XML tree, creates an XmlReader from the XML tree, creates a new document, and then creates an XmlWriter to write into the new document. It then invokes the XSLT transformation, passing in XmlReader and XmlWriter. After the transformation successfully completes, the new XML tree is populated with the results of the transformation.

```
string xslMarkup = @"<?xml version='1.0'?>
<xsl:stylesheet xmlns:xsl='http://www.w3.org/1999/XSL/Transform' version='1.0'>
    <xsl:template match='/Parent'>
        <Root>
            <C1>
            <xsl:value-of select='Child1'/>
            </C1>
            <C2>
            <xsl:value-of select='Child2'/>
            </C2>
        </Root>
    </xsl:template>
</xsl:stylesheet>";

XDocument xmlTree = new XDocument(
    new XElement("Parent",
        new XElement("Child1", "Child1 data"),
        new XElement("Child2", "Child2 data")
    )
);

XDocument newTree = new XDocument();
using (XmlWriter writer = newTree.CreateWriter())
{
    // Load the style sheet.
    XslCompiledTransform xslt = new XslCompiledTransform();
    xslt.Load(XmlReader.Create(new StringReader(xslMarkup)));

    // Execute the transformation and output the results to a writer.
    xslt.Transform(xmlTree.CreateReader(), writer);
}

Console.WriteLine(newTree);
```

This example produces the following output:

```
<Root>
  <C1>Child1 data</C1>
  <C2>Child2 data</C2>
</Root>
```

See also

- CreateWriter
- XmlWriter
- XslCompiledTransform
- Creating XML Trees (C#)

How to: Validate Using XSD (LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

The System.Xml.Schema namespace contains extension methods that make it easy to validate an XML tree against an XML Schema Definition Language (XSD) file. For more information, see the Validate method documentation.

Example

The following example creates an XmlSchemaSet, then validates two XDocument objects against the schema set. One of the documents is valid, the other is not.

```
string xsdMarkup =
    @"<xsd:schema xmlns:xsd='http://www.w3.org/2001/XMLSchema'>
       <xsd:element name='Root'>
        <xsd:complexType>
         <xsd:sequence>
          <xsd:element name='Child1' minOccurs='1' maxOccurs='1'/>
          <xsd:element name='Child2' minOccurs='1' maxOccurs='1'/>
         </xsd:sequence>
        </xsd:complexType>
       </xsd:element>
      </xsd:schema>";
XmlSchemaSet schemas = new XmlSchemaSet();
schemas.Add("", XmlReader.Create(new StringReader(xsdMarkup)));

XDocument doc1 = new XDocument(
    new XElement("Root",
        new XElement("Child1", "content1"),
        new XElement("Child2", "content1")
    )
);

XDocument doc2 = new XDocument(
    new XElement("Root",
        new XElement("Child1", "content1"),
        new XElement("Child3", "content1")
    )
);

Console.WriteLine("Validating doc1");
bool errors = false;
doc1.Validate(schemas, (o, e) =>
                     {
                         Console.WriteLine("{0}", e.Message);
                         errors = true;
                     });
Console.WriteLine("doc1 {0}", errors ? "did not validate" : "validated");

Console.WriteLine();
Console.WriteLine("Validating doc2");
errors = false;
doc2.Validate(schemas, (o, e) =>
                     {
                         Console.WriteLine("{0}", e.Message);
                         errors = true;
                     });
Console.WriteLine("doc2 {0}", errors ? "did not validate" : "validated");
```

This example produces the following output:

```
Validating doc1
doc1 validated

Validating doc2
The element 'Root' has invalid child element 'Child3'. List of possible elements expected: 'Child2'.
doc2 did not validate
```

Example

The following example validates that the XML document from Sample XML File: Customers and Orders (LINQ to XML) is valid per the schema from Sample XSD File: Customers and Orders. It then modifies the source XML document. It changes the `CustomerID` attribute on the first customer. After the change, orders will then refer to a customer that does not exist, so the XML document will no longer validate.

This example uses the following XML document: Sample XML File: Customers and Orders (LINQ to XML).

This example uses the following XSD schema: Sample XSD File: Customers and Orders.

```
XmlSchemaSet schemas = new XmlSchemaSet();
schemas.Add("", "CustomersOrders.xsd");

Console.WriteLine("Attempting to validate");
XDocument custOrdDoc = XDocument.Load("CustomersOrders.xml");
bool errors = false;
custOrdDoc.Validate(schemas, (o, e) =>
                     {
                         Console.WriteLine("{0}", e.Message);
                         errors = true;
                     });
Console.WriteLine("custOrdDoc {0}", errors ? "did not validate" : "validated");

Console.WriteLine();
// Modify the source document so that it will not validate.
custOrdDoc.Root.Element("Orders").Element("Order").Element("CustomerID").Value = "AAAAA";
Console.WriteLine("Attempting to validate after modification");
errors = false;
custOrdDoc.Validate(schemas, (o, e) =>
                     {
                         Console.WriteLine("{0}", e.Message);
                         errors = true;
                     });
Console.WriteLine("custOrdDoc {0}", errors ? "did not validate" : "validated");
```

This example produces the following output:

```
Attempting to validate
custOrdDoc validated

Attempting to validate after modification
The key sequence 'AAAAA' in Keyref fails to refer to some key.
custOrdDoc did not validate
```

See also

- Validate
- Creating XML Trees (C#)

Valid Content of XElement and XDocument Objects

1/23/2019 • 2 minutes to read • Edit Online

This topic describes the valid arguments that can be passed to constructors and methods that you use to add content to elements and documents.

Valid Content

Queries often evaluate to IEnumerable<T> of XElement or IEnumerable<T> of XAttribute. You can pass collections of XElement or XAttribute objects to the XElement constructor. Therefore, it is convenient to pass the results of a query as content into methods and constructors that you use to populate XML trees.

When adding simple content, various types can be passed to this method. Valid types include the following:

- String
- Double
- Single
- Decimal
- Boolean
- DateTime
- TimeSpan
- DateTimeOffset
- Any type that implements `Object.ToString`.
- Any type that implements IEnumerable<T>.

When adding complex content, various types can be passed to this method:

- XObject
- XNode
- XAttribute
- Any type that implements IEnumerable<T>

If an object implements IEnumerable<T>, the collection in the object is enumerated, and all items in the collection are added. If the collection contains XNode or XAttribute objects, each item in the collection is added separately. If the collection contains text (or objects that are converted to text), the text in the collection is concatenated and added as a single text node.

If content is `null`, nothing is added. When passing a collection items in the collection can be `null`. A `null` item in the collection has no effect on the tree.

An added attribute must have a unique name within its containing element.

When adding XNode or XAttribute objects, if the new content has no parent, then the objects are simply attached to the XML tree. If the new content already is parented and is part of another XML tree, then the new content is cloned, and the newly cloned content is attached to the XML tree.

Valid Content for Documents

Attributes and simple content cannot be added to a document.

There are not many scenarios that require you to create an XDocument. Instead, you can usually create your XML trees with an XElement root node. Unless you have a specific requirement to create a document (for example, because you have to create processing instructions and comments at the top level, or you have to support document types), it is often more convenient to use XElement as your root node.

Valid content for a document includes the following:

- Zero or one XDocumentType objects. The document types must come before the element.
- Zero or one element.
- Zero or more comments.
- Zero or more processing instructions.
- Zero or more text nodes that contain only white space.

Constructors and Functions that Allow Adding Content

The following methods allow you to add child content to an XElement or an XDocument:

METHOD	DESCRIPTION
XElement	Constructs an XElement.
XDocument	Constructs a XDocument.
Add	Adds to the end of the child content of the XElement or XDocument.
AddAfterSelf	Adds content after the XNode.
AddBeforeSelf	Adds content before the XNode.
AddFirst	Adds content at the beginning of the child content of the XContainer.
ReplaceAll	Replaces all content (child nodes and attributes) of an XElement.
ReplaceAttributes	Replaces the attributes of an XElement.
ReplaceNodes	Replaces the children nodes with new content.
ReplaceWith	Replaces a node with new content.

See also

- Creating XML Trees (C#)

Working with XML Namespaces (C#)

1/23/2019 • 2 minutes to read • Edit Online

The topics in this section describe how LINQ to XML supports namespaces.

In This Section

TOPIC	DESCRIPTION
Namespaces Overview (LINQ to XML)	This topic introduces namespaces, the XName class, and the XNamespace class.
How to: Create a Document with Namespaces (C#) (LINQ to XML)	Shows how to create documents with namespaces.
How to: Control Namespace Prefixes (C#) (LINQ to XML)	Shows how to control namespace prefixes by inserting namespace attributes into the XML tree.
Scope of Default Namespaces in C#	Demonstrates the appropriate way to write queries for XML in the default namespace.
How to: Write Queries on XML in Namespaces (C#)	Demonstrates how to specify XML namespaces in C# LINQ to XML queries.

See also

- Programming Guide (LINQ to XML) (C#)

Namespaces Overview (LINQ to XML)

1/23/2019 • 2 minutes to read • Edit Online

This topic introduces namespaces, the XName class, and the XNamespace class.

XML Names

XML names are often a source of complexity in XML programming. An XML name consists of an XML namespace (also called an XML namespace URI) and a local name. An XML namespace is similar to a namespace in a .NET Framework-based program. It enables you to uniquely qualify the names of elements and attributes. This helps avoid name conflicts between various parts of an XML document. When you have declared an XML namespace, you can select a local name that only has to be unique within that namespace.

Another aspect of XML names is XML *namespace prefixes*. XML prefixes cause most of the complexity of XML names. These prefixes enable you to create a shortcut for an XML namespace, which makes the XML document more concise and understandable. However, XML prefixes depend on their context to have meaning, which adds complexity. For example, the XML prefix `aw` could be associated with one XML namespace in one part of an XML tree, and with a different XML namespace in a different part of the XML tree.

One of the advantages of using LINQ to XML with C# is that you do not have to use XML prefixes. When LINQ to XML loads or parses an XML document, each XML prefix is resolved to its corresponding XML namespace. After that, when you work with a document that uses namespaces, you almost always access the namespaces through the namespace URI, and not through the namespace prefix. When developers work with XML names in LINQ to XML they always work with a fully-qualified XML name (that is, an XML namespace and a local name). However, when necessary, LINQ to XML allows you to work with and control namespace prefixes.

In LINQ to XML, the class that represents XML names is XName. XML names appear frequently throughout the LINQ to XML API, and wherever an XML name is required, you will find an XName parameter. However, you rarely work directly with an XName. XName contains an implicit conversion from string.

For more information, see XNamespace and XName.

See also

- Working with XML Namespaces (C#)

How to: Create a Document with Namespaces (C#) (LINQ to XML)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows how to create documents with namespaces.

Example

To create an element or an attribute that is in a namespace, you first declare and initialize an XNamespace object. You then use the addition operator overload to combine the namespace with the local name, expressed as a string.

The following example creates a document with one namespace. By default, LINQ to XML serializes this document with a default namespace.

```
// Create an XML tree in a namespace.
XNamespace aw = "http://www.adventure-works.com";
XElement root = new XElement(aw + "Root",
    new XElement(aw + "Child", "child content")
);
Console.WriteLine(root);
```

This example produces the following output:

```
<Root xmlns="http://www.adventure-works.com">
  <Child>child content</Child>
</Root>
```

Example

The following example creates a document with one namespace. It also creates an attribute that declares the namespace with a namespace prefix. To create an attribute that declares a namespace with a prefix, you create an attribute where the name of the attribute is the namespace prefix, and this name is in the Xmlns namespace. The value of this attribute is the URI of the namespace.

```
// Create an XML tree in a namespace, with a specified prefix
XNamespace aw = "http://www.adventure-works.com";
XElement root = new XElement(aw + "Root",
    new XAttribute(XNamespace.Xmlns + "aw", "http://www.adventure-works.com"),
    new XElement(aw + "Child", "child content")
);
Console.WriteLine(root);
```

This example produces the following output:

```
<aw:Root xmlns:aw="http://www.adventure-works.com">
  <aw:Child>child content</aw:Child>
</aw:Root>
```

Example

The following example shows the creation of a document that contains two namespaces. One is the default namespace. Another is a namespace with a prefix.

By including namespace attributes in the root element, the namespaces are serialized so that `http://www.adventure-works.com` is the default namespace, and `www.fourthcoffee.com` is serialized with a prefix of "fc". To create an attribute that declares a default namespace, you create an attribute with the name "xmlns", without a namespace. The value of the attribute is the default namespace URI.

```
// The http://www.adventure-works.com namespace is forced to be the default namespace.
XNamespace aw = "http://www.adventure-works.com";
XNamespace fc = "www.fourthcoffee.com";
XElement root = new XElement(aw + "Root",
    new XAttribute("xmlns", "http://www.adventure-works.com"),
    new XAttribute(XNamespace.Xmlns + "fc", "www.fourthcoffee.com"),
    new XElement(fc + "Child",
        new XElement(aw + "DifferentChild", "other content")
    ),
    new XElement(aw + "Child2", "c2 content"),
    new XElement(fc + "Child3", "c3 content")
);
Console.WriteLine(root);
```

This example produces the following output:

```
<Root xmlns="http://www.adventure-works.com" xmlns:fc="www.fourthcoffee.com">
  <fc:Child>
    <DifferentChild>other content</DifferentChild>
  </fc:Child>
  <Child2>c2 content</Child2>
  <fc:Child3>c3 content</fc:Child3>
</Root>
```

Example

The following example creates a document that contains two namespaces, both with namespace prefixes.

```
XNamespace aw = "http://www.adventure-works.com";
XNamespace fc = "www.fourthcoffee.com";
XElement root = new XElement(aw + "Root",
    new XAttribute(XNamespace.Xmlns + "aw", aw.NamespaceName),
    new XAttribute(XNamespace.Xmlns + "fc", fc.NamespaceName),
    new XElement(fc + "Child",
        new XElement(aw + "DifferentChild", "other content")
    ),
    new XElement(aw + "Child2", "c2 content"),
    new XElement(fc + "Child3", "c3 content")
);
Console.WriteLine(root);
```

This example produces the following output:

```
<aw:Root xmlns:aw="http://www.adventure-works.com" xmlns:fc="www.fourthcoffee.com">
  <fc:Child>
    <aw:DifferentChild>other content</aw:DifferentChild>
  </fc:Child>
  <aw:Child2>c2 content</aw:Child2>
  <fc:Child3>c3 content</fc:Child3>
</aw:Root>
```

Example

Another way to accomplish the same result is to use expanded names instead of declaring and creating an XNamespace object.

This approach has performance implications. Each time you pass a string that contains an expanded name to LINQ to XML, LINQ to XML must parse the name, find the atomized namespace, and find the atomized name. This process takes CPU time. If performance is important, you might want to declare and use an XNamespace object explicitly.

If performance is an important issue, see Pre-Atomization of XName Objects (LINQ to XML) (C#) for more information

```
// Create an XML tree in a namespace, with a specified prefix
XElement root = new XElement("{http://www.adventure-works.com}Root",
    new XAttribute(XNamespace.Xmlns + "aw", "http://www.adventure-works.com"),
    new XElement("{http://www.adventure-works.com}Child", "child content")
);
Console.WriteLine(root);
```

This example produces the following output:

```
<aw:Root xmlns:aw="http://www.adventure-works.com">
  <aw:Child>child content</aw:Child>
</aw:Root>
```

See also

- Working with XML Namespaces (C#)

How to: Control Namespace Prefixes (C#) (LINQ to XML)

1/23/2019 • 2 minutes to read • Edit Online

This topic describes how you can control namespace prefixes when serializing an XML tree.

In many situations, it is not necessary to control namespace prefixes.

However, certain XML programming tools require specific control of namespace prefixes. For example, you might be manipulating an XSLT style sheet or a XAML document that contains embedded XPath expressions that refer to specific namespace prefixes; in this case, it is important that the document be serialized with those specific prefixes.

This is the most common reason for controlling namespace prefixes.

Another common reason for controlling namespace prefixes is that you want users to edit the XML document manually, and you want to create namespace prefixes that are convenient for the user to type. For example, you might be generating an XSD document. Conventions for schemas suggest that you use either `xs` or `xsd` as the prefix for the schema namespace.

To control namespace prefixes, you insert attributes that declare namespaces. If you declare the namespaces with specific prefixes, LINQ to XML will attempt to honor the namespace prefixes when serializing.

To create an attribute that declares a namespace with a prefix, you create an attribute where the namespace of the name of the attribute is Xmlns, and the name of the attribute is the namespace prefix. The value of the attribute is the URI of the namespace.

Example

This example declares two namespaces. It specifies that the `http://www.adventure-works.com` namespace has the prefix of `aw`, and that the `www.fourthcoffee.com` namespace has the prefix of `fc`.

```
XNamespace aw = "http://www.adventure-works.com";
XNamespace fc = "www.fourthcoffee.com";
XElement root = new XElement(aw + "Root",
    new XAttribute(XNamespace.Xmlns + "aw", "http://www.adventure-works.com"),
    new XAttribute(XNamespace.Xmlns + "fc", "www.fourthcoffee.com"),
    new XElement(fc + "Child",
        new XElement(aw + "DifferentChild", "other content")
    ),
    new XElement(aw + "Child2", "c2 content"),
    new XElement(fc + "Child3", "c3 content")
);
Console.WriteLine(root);
```

This example produces the following output:

```
<aw:Root xmlns:aw="http://www.adventure-works.com" xmlns:fc="www.fourthcoffee.com">
  <fc:Child>
    <aw:DifferentChild>other content</aw:DifferentChild>
  </fc:Child>
  <aw:Child2>c2 content</aw:Child2>
  <fc:Child3>c3 content</fc:Child3>
</aw:Root>
```

See also

- Working with XML Namespaces (C#)

Scope of Default Namespaces in C#

1/23/2019 • 2 minutes to read • Edit Online

Default namespaces as represented in the XML tree are not in scope for queries. If you have XML that is in a default namespace, you still must declare an XNamespace variable, and combine it with the local name to make a qualified name to be used in the query.

One of the most common problems when querying XML trees is that if the XML tree has a default namespace, the developer sometimes writes the query as though the XML were not in a namespace.

The first set of examples in this topic shows a typical way that XML in a default namespace is loaded, but is queried improperly.

The second set of examples show the necessary corrections so that you can query XML in a namespace.

Example

This example shows the creation of XML in a namespace, and a query that returns an empty result set.

Code

```
XElement root = XElement.Parse(
@"<Root xmlns='http://www.adventure-works.com'>
    <Child>1</Child>
    <Child>2</Child>
    <Child>3</Child>
    <AnotherChild>4</AnotherChild>
    <AnotherChild>5</AnotherChild>
    <AnotherChild>6</AnotherChild>
</Root>");
IEnumerable<XElement> c1 =
    from el in root.Elements("Child")
    select el;
Console.WriteLine("Result set follows:");
foreach (XElement el in c1)
    Console.WriteLine((int)el);
Console.WriteLine("End of result set");
```

Comments

This example produces the following result:

```
Result set follows:
End of result set
```

Example

This example shows the creation of XML in a namespace, and a query that is coded properly.

In contrast to the incorrectly coded example above, the correct approach when using C# is to declare and initialize an XNamespace object, and to use it when specifying XName objects. In this case, the argument to the Elements method is an XName object.

Code

```
XElement root = XElement.Parse(
@"<Root xmlns='http://www.adventure-works.com'>
    <Child>1</Child>
    <Child>2</Child>
    <Child>3</Child>
    <AnotherChild>4</AnotherChild>
    <AnotherChild>5</AnotherChild>
    <AnotherChild>6</AnotherChild>
</Root>");
XNamespace aw = "http://www.adventure-works.com";
IEnumerable<XElement> c1 =
    from el in root.Elements(aw + "Child")
    select el;
Console.WriteLine("Result set follows:");
foreach (XElement el in c1)
    Console.WriteLine((int)el);
Console.WriteLine("End of result set");
```

Comments

This example produces the following result:

```
Result set follows:
1
2
3
End of result set
```

See also

- Working with XML Namespaces (C#)

How to: Write Queries on XML in Namespaces (C#)

1/23/2019 • 2 minutes to read • Edit Online

To write a query on XML that is in a namespace, you must use XName objects that have the correct namespace.

For C#, the most common approach is to initialize an XNamespace using a string that contains the URI, then use the addition operator overload to combine the namespace with the local name.

The first set of examples in this topic shows how to create an XML tree in a default namespace. The second set shows how to create an XML tree in a namespace with a prefix.

Example

The following example creates an XML tree that is in a default namespace. It then retrieves a collection of elements.

```
XNamespace aw = "http://www.adventure-works.com";
XElement root = XElement.Parse(
@"<Root xmlns='http://www.adventure-works.com'>
    <Child>1</Child>
    <Child>2</Child>
    <Child>3</Child>
    <AnotherChild>4</AnotherChild>
    <AnotherChild>5</AnotherChild>
    <AnotherChild>6</AnotherChild>
</Root>");
IEnumerable<XElement> c1 =
    from el in root.Elements(aw + "Child")
    select el;
foreach (XElement el in c1)
    Console.WriteLine((int)el);
```

This example produces the following output:

```
1
2
3
```

Example

In C#, you write queries in the same way regardless of whether you are writing queries on an XML tree that uses a namespace with a prefix or on an XML tree with a default namespace.

The following example creates an XML tree that is in a namespace with a prefix. It then retrieves a collection of elements.

```
XNamespace aw = "http://www.adventure-works.com";
XElement root = XElement.Parse(
@"<aw:Root xmlns:aw='http://www.adventure-works.com'>
    <aw:Child>1</aw:Child>
    <aw:Child>2</aw:Child>
    <aw:Child>3</aw:Child>
    <aw:AnotherChild>4</aw:AnotherChild>
    <aw:AnotherChild>5</aw:AnotherChild>
    <aw:AnotherChild>6</aw:AnotherChild>
</aw:Root>");
IEnumerable<XElement> c1 =
    from el in root.Elements(aw + "Child")
    select el;
foreach (XElement el in c1)
    Console.WriteLine((int)el);
```

This example produces the following output:

```
1
2
3
```

See also

- Working with XML Namespaces (C#)

Serializing XML Trees (C#)

1/23/2019 • 2 minutes to read • Edit Online

Serializing an XML tree means generating XML from the XML tree. You can serialize to a file, to a concrete implementation of the TextWriter class, or to a concrete implementation of an XmlWriter.

You can control various aspects of serialization. For example, you can control whether to indent the serialized XML, and whether to write an XML declaration.

In This Section

TOPIC	DESCRIPTION
Preserving White Space While Serializing	Describes how to control white space behavior when you serialize XML trees.
Serializing with an XML Declaration (C#)	Describes how to serialize an XML tree that includes an XML declaration.
Serializing to Files, TextWriters, and XmlWriters	Describes how to serialize a document to a File, a TextWriter, or an XmlWriter.
Serializing to an XmlReader (Invoking XSLT) (C#)	Describes how to create a XmlReader that enables another module to read the contents of an XML tree.

See also

- Programming Guide (LINQ to XML) (C#)

Preserving White Space While Serializing

1/23/2019 • 2 minutes to read • Edit Online

This topic describes how to control white space when serializing an XML tree.

A common scenario is to read indented XML, create an in-memory XML tree without any white-space text nodes (that is, not preserving white space), perform some operations on the XML, and then save the XML with indentation. When you serialize the XML with formatting, only significant white space in the XML tree is preserved. This is the default behavior for LINQ to XML.

Another common scenario is to read and modify XML that has already been intentionally indented. You might not want to change this indentation in any way. To do this in LINQ to XML, you preserve white space when you load or parse the XML and disable formatting when you serialize the XML.

White-Space Behavior of Methods that Serialize XML Trees

The following methods in the XElement and XDocument classes serialize an XML tree. You can serialize an XML tree to a file, a TextReader, or an XmlReader. The `ToString` method serializes to a string.

- XElement.Save
- XDocument.Save
- ToString
- ToString

If the method does not take SaveOptions as an argument, then the method will format (indent) the serialized XML. In this case, all insignificant white space in the XML tree is discarded.

If the method does take SaveOptions as an argument, then you can specify that the method not format (indent) the serialized XML. In this case, all white space in the XML tree is preserved.

See also

- Serializing XML Trees (C#)

Serializing with an XML Declaration (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic describes how to control whether serialization generates an XML declaration.

XML Declaration Generation

Serializing to a File or a TextWriter using the XElement.Save method or the XDocument.Save method generates an XML declaration. When you serialize to an XmlWriter, the writer settings (specified in an XmlWriterSettings object) determine whether an XML declaration is generated or not.

If you are serializing to a string using the `ToString` method, the resulting XML will not include an XML declaration.

Serializing with an XML Declaration

The following example creates an XElement, saves the document to a file, and then prints the file to the console:

```
XElement root = new XElement("Root",
    new XElement("Child", "child content")
);
root.Save("Root.xml");
string str = File.ReadAllText("Root.xml");
Console.WriteLine(str);
```

This example produces the following output:

```
<?xml version="1.0" encoding="utf-8"?>
<Root>
  <Child>child content</Child>
</Root>
```

Serializing without an XML Declaration

The following example shows how to save an XElement to an XmlWriter.

```
StringBuilder sb = new StringBuilder();
XmlWriterSettings xws = new XmlWriterSettings();
xws.OmitXmlDeclaration = true;

using (XmlWriter xw = XmlWriter.Create(sb, xws)) {
    XElement root = new XElement("Root",
        new XElement("Child", "child content")
    );
    root.Save(xw);
}
Console.WriteLine(sb.ToString());
```

This example produces the following output:

```
<Root><Child>child content</Child></Root>
```

See also

- Serializing XML Trees (C#)

Serializing to Files, TextWriters, and XmlWriters

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You can serialize XML trees to a File, a TextWriter, or an XmlWriter.

You can serialize any XML component, including XDocument and XElement, to a string by using the `ToString` method.

If you want to suppress formatting when serializing to a string, you can use the XNode.ToString method.

Thedefault behavior when serializing to a file is to format (indent) the resulting XML document. When you indent, the insignificant white space in the XML tree is not preserved. To serialize with formatting, use one of the overloads of the following methods that do not take SaveOptions as an argument:

- XDocument.Save
- XElement.Save

If you want the option not to indent and to preserve the insignificant white space in the XML tree, use one of the overloads of the following methods that takes SaveOptions as an argument:

- XDocument.Save
- XElement.Save

For examples, see the appropriate reference topic.

See also

- Serializing XML Trees (C#)

Serializing to an XmlReader (Invoking XSLT) (C#)

1/23/2019 • 2 minutes to read • Edit Online

When you use the System.Xml interoperability capabilities of LINQ to XML, you can use CreateReader to create an XmlReader. The module that reads from this XmlReader reads the nodes from the XML tree and processes them accordingly.

Invoking an XSLT Transformation

One possible use for this method is when invoking an XSLT transformation. You can create an XML tree, create an XmlReader from the XML tree, create a new document, and then create an XmlWriter to write into the new document. Then, you can invoke the XSLT transformation, passing in XmlReader and XmlWriter. After the transformation successfully completes, the new XML tree is populated with the results of the transformation.

```
string xslMarkup = @"<?xml version='1.0'?>
<xsl:stylesheet xmlns:xsl='http://www.w3.org/1999/XSL/Transform' version='1.0'>
    <xsl:template match='/Parent'>
        <Root>
            <C1>
            <xsl:value-of select='Child1'/>
            </C1>
            <C2>
            <xsl:value-of select='Child2'/>
            </C2>
        </Root>
    </xsl:template>
</xsl:stylesheet>";

XDocument xmlTree = new XDocument(
    new XElement("Parent",
        new XElement("Child1", "Child1 data"),
        new XElement("Child2", "Child2 data")
    )
);

XDocument newTree = new XDocument();
using (XmlWriter writer = newTree.CreateWriter()) {
    // Load the style sheet.
    XslCompiledTransform xslt = new XslCompiledTransform();
    xslt.Load(XmlReader.Create(new StringReader(xslMarkup)));

    // Execute the transformation and output the results to a writer.
    xslt.Transform(xmlTree.CreateReader(), writer);
}

Console.WriteLine(newTree);
```

This example produces the following output:

```
<Root>
  <C1>Child1 data</C1>
  <C2>Child2 data</C2>
</Root>
```

See also

- Serializing XML Trees (C#)

LINQ to XML Axes (C#)

1/23/2019 • 2 minutes to read • Edit Online

After you have created an XML tree or loaded an XML document into an XML tree, you can query it to find elements and attributes and retrieve their values.

Before you can write any queries, you must understand the LINQ to XML axes. There are two kinds of axis methods: First, there are the methods that you call on a single XElement object, XDocument object, or XNode object. These methods operate on a single object and return a collection of XElement, XAttribute, or XNode objects. Second, there are extension methods that operate on collections and return collections. The extension methods enumerate the source collection, call the appropriate axis method on each item in the collection, and concatenate the results.

In This Section

TOPIC	DESCRIPTION
LINQ to XML Axes Overview (C#)	Defines axes, and explains how they are used in the context of LINQ to XML queries.
How to: Retrieve a Collection of Elements (LINQ to XML) (C#)	Introduces the Elements method. This method retrieves a collection of the child elements of an element.
How to: Retrieve the Value of an Element (LINQ to XML) (C#)	Shows how to get the values of elements.
How to: Filter on Element Names (LINQ to XML) (C#)	Shows how to filter on element names when using axes.
How to: Chain Axis Method Calls (LINQ to XML) (C#)	Shows how to chain calls to axes methods.
How to: Retrieve a Single Child Element (LINQ to XML) (C#)	Shows how to retrieve a single child element of an element, given the tag name of the child element.
How to: Retrieve a Collection of Attributes (LINQ to XML) (C#)	Introduces the Attributes method. This method retrieves the attributes of an element.
How to: Retrieve a Single Attribute (LINQ to XML) (C#)	Shows how to retrieve a single attribute of an element, given the attribute name.
How to: Retrieve the Value of an Attribute (LINQ to XML) (C#)	Shows how to get the values of attributes.
How to: Retrieve the Shallow Value of an Element (C#)	Shows how to retrieve the shallow value of an element.

See also

- Extension Methods
- Programming Guide (LINQ to XML) (C#)

LINQ to XML Axes Overview (C#)

1/23/2019 • 3 minutes to read • Edit Online

After you have created an XML tree or loaded an XML document into an XML tree, you can query it to find elements and attributes and retrieve their values. You retrieve collections through the *axis methods*, also called *axes*. Some of the axes are methods in the XElement and XDocument classes that return IEnumerable<T> collections. Some of the axes are extension methods in the Extensions class. The axes that are implemented as extension methods operate on collections, and return collections.

As described in XElement Class Overview, an XElement object represents a single element node. The content of an element can be complex (sometimes called structured content), or it can be a simple element. A simple element can be empty or can contain a value. If the node contains structured content, you can use the various axis methods to retrieve enumerations of descendant elements. The most commonly used axis methods are Elements and Descendants.

In addition to the axis methods, which return collections, there are two more methods that you will commonly use in LINQ to XML queries. The Element method returns a single XElement. The Attribute method returns a single XAttribute.

For many purposes, LINQ queries provide the most powerful way to examine a tree, extract data from it, and transform it. LINQ queries operate on objects that implement IEnumerable<T>, and the LINQ to XML axes return IEnumerable<T> of XElement collections, and IEnumerable<T> of XAttribute collections. You need these collections to perform your queries.

In addition to the axis methods that retrieve collections of elements and attributes, there are axis methods that allow you to iterate through the tree in great detail. For example, instead of dealing with elements and attributes, you can work with the nodes of the tree. Nodes are a finer level of granularity than elements and attributes. When working with nodes, you can examine XML comments, text nodes, processing instructions, and more. This functionality is important, for example, to someone who is writing a word processor and wants to save documents as XML. However, the majority of XML programmers are primarily concerned with elements, attributes, and their values.

Methods for Retrieving a Collection of Elements

The following is a summary of the methods of the XElement class (or its base classes) that you call on an XElement to return a collection of elements.

METHOD	DESCRIPTION
XNode.Ancestors	Returns an IEnumerable<T> of XElement of the ancestors of this element. An overload returns an IEnumerable<T> of XElement of the ancestors that have the specified XName.
XContainer.Descendants	Returns an IEnumerable<T> of XElement of the descendants of this element. An overload returns an IEnumerable<T> of XElement of the descendants that have the specified XName.
XContainer.Elements	Returns an IEnumerable<T> of XElement of the child elements of this element. An overload returns an IEnumerable<T> of XElement of the child elements that have the specified XName.

METHOD	DESCRIPTION
XNode.ElementsAfterSelf	Returns an IEnumerable<T> of XElement of the elements that come after this element. An overload returns an IEnumerable<T> of XElement of the elements after this element that have the specified XName.
XNode.ElementsBeforeSelf	Returns an IEnumerable<T> of XElement of the elements that come before this element. An overload returns an IEnumerable<T> of XElement of the elements before this element that have the specified XName.
XElement.AncestorsAndSelf	Returns an IEnumerable<T> of XElement of this element and its ancestors. An overload returns an IEnumerable<T> of XElement of the elements that have the specified XName.
XElement.DescendantsAndSelf	Returns an IEnumerable<T> of XElement of this element and its descendants. An overload returns an IEnumerable<T> of XElement of the elements that have the specified XName.

Method for Retrieving a Single Element

The following method retrieves a single child from an XElement object.

METHOD	DESCRIPTION
XContainer.Element	Returns the first child XElement object that has the specified XName.

Method for Retrieving a Collection of Attributes

The following method retrieves attributes from an XElement object.

METHOD	DESCRIPTION
XElement.Attributes	Returns an IEnumerable<T> of XAttribute of all of the attributes.

Method for Retrieving a Single Attribute

The following method retrieves a single attribute from an XElement object.

METHOD	DESCRIPTION
XElement.Attribute	Returns the XAttribute that has the specified XName.

See also

- LINQ to XML Axes (C#)

How to: Retrieve a Collection of Elements (LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic demonstrates the Elements method. This method retrieves a collection of the child elements of an element.

Example

This example iterates through the child elements of the `purchaseOrder` element.

This example uses the following XML document: Sample XML File: Typical Purchase Order (LINQ to XML).

```
XElement po = XElement.Load("PurchaseOrder.xml");
IEnumerable<XElement> childElements =
    from el in po.Elements()
    select el;
foreach (XElement el in childElements)
    Console.WriteLine("Name: " + el.Name);
```

This example produces the following output.

```
Name: Address
Name: Address
Name: DeliveryNotes
Name: Items
```

See also

- LINQ to XML Axes (C#)

How to: Retrieve the Value of an Element (LINQ to XML) (C#)

1/23/2019 • 3 minutes to read • Edit Online

This topic shows how to get the value of elements. There are two main ways to do this. One way is to cast an XElement or an XAttribute to the desired type. The explicit conversion operator then converts the contents of the element or attribute to the specified type and assigns it to your variable. Alternatively, you can use the XElement.Value property or the XAttribute.Value property.

With C#, however, casting is generally the better approach. If you cast the element or attribute to a nullable type, the code is simpler to write when retrieving the value of an element (or attribute) that might or might not exist. The last example in this topic demonstrates this. However, you cannot set the contents of an element through casting, as you can through XElement.Value property.

Example

To retrieve the value of an element, you just cast the XElement object to your desired type. You can always cast an element to a string, as follows:

```
XElement e = new XElement("StringElement", "abcde");
Console.WriteLine(e);
Console.WriteLine("Value of e:" + (string)e);
```

This example produces the following output:

```
<StringElement>abcde</StringElement>
Value of e:abcde
```

Example

You can also cast elements to types other than string. For example, if you have an element that contains an integer, you can cast it to `int`, as shown in the following code:

```
XElement e = new XElement("Age", "44");
Console.WriteLine(e);
Console.WriteLine("Value of e:" + (int)e);
```

This example produces the following output:

```
<Age>44</Age>
Value of e:44
```

LINQ to XML provides explicit cast operators for the following data types: `string`, `bool`, `bool?`, `int`, `int?`, `uint`, `uint?`, `long`, `long?`, `ulong`, `ulong?`, `float`, `float?`, `double`, `double?`, `decimal`, `decimal?`, `DateTime`, `DateTime?`, `TimeSpan`, `TimeSpan?`, `GUID`, and `GUID?`.

LINQ to XML provides the same cast operators for XAttribute objects.

Example

You can use the Value property to retrieve the contents of an element:

```
XElement e = new XElement("StringElement", "abcde");
Console.WriteLine(e);
Console.WriteLine("Value of e:" + e.Value);
```

This example produces the following output:

```
<StringElement>abcde</StringElement>
Value of e:abcde
```

Example

Sometimes you try to retrieve the value of an element even though you are not sure it exists. In this case, when you assign the casted element to a nullable type (either `string` or one of the nullable types in the .NET Framework), if the element does not exist the assigned variable is just set to `null`. The following code shows that when the element might or might not exist, it is easier to use casting than to use the Value property.

```
XElement root = new XElement("Root",
    new XElement("Child1", "child 1 content"),
    new XElement("Child2", "2")
);

// The following assignments show why it is easier to use
// casting when the element might or might not exist.

string c1 = (string)root.Element("Child1");
Console.WriteLine("c1:{0}", c1 == null ? "element does not exist" : c1);

int? c2 = (int?)root.Element("Child2");
Console.WriteLine("c2:{0}", c2 == null ? "element does not exist" : c2.ToString());

string c3 = (string)root.Element("Child3");
Console.WriteLine("c3:{0}", c3 == null ? "element does not exist" : c3);

int? c4 = (int?)root.Element("Child4");
Console.WriteLine("c4:{0}", c4 == null ? "element does not exist" : c4.ToString());

Console.WriteLine();

// The following assignments show the required code when using
// the Value property when the element might or might not exist.
// Notice that this is more difficult than the casting approach.

XElement e1 = root.Element("Child1");
string v1;
if (e1 == null)
    v1 = null;
else
    v1 = e1.Value;
Console.WriteLine("v1:{0}", v1 == null ? "element does not exist" : v1);

XElement e2 = root.Element("Child2");
int? v2;
if (e2 == null)
    v2 = null;
else
    v2 = Int32.Parse(e2.Value);
Console.WriteLine("v2:{0}", v2 == null ? "element does not exist" : v2.ToString());

XElement e3 = root.Element("Child3");
string v3;
if (e3 == null)
    v3 = null;
else
    v3 = e3.Value;
Console.WriteLine("v3:{0}", v3 == null ? "element does not exist" : v3);

XElement e4 = root.Element("Child4");
int? v4;
if (e4 == null)
    v4 = null;
else
    v4 = Int32.Parse(e4.Value);
Console.WriteLine("v4:{0}", v4 == null ? "element does not exist" : v4.ToString());
```

This code produces the following output:

```
c1:child 1 content
c2:2
c3:element does not exist
c4:element does not exist

v1:child 1 content
v2:2
v3:element does not exist
v4:element does not exist
```

In general, you can write simpler code when using casting to retrieve the contents of elements and attributes.

See also

- LINQ to XML Axes (C#)

How to: Filter on Element Names (LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

When you call one of the methods that return IEnumerable<T> of XElement, you can filter on the element name.

Example

This example retrieves a collection of descendants that is filtered to contain only descendants with the specified name.

This example uses the following XML document: Sample XML File: Typical Purchase Order (LINQ to XML).

```
XElement po = XElement.Load("PurchaseOrder.xml");
IEnumerable<XElement> items =
    from el in po.Descendants("ProductName")
    select el;
foreach(XElement prdName in items)
    Console.WriteLine(prdName.Name + ":" + (string) prdName);
```

This code produces the following output:

```
ProductName:Lawnmower
ProductName:Baby Monitor
```

The other methods that return IEnumerable<T> of XElement collections follow the same pattern. Their signatures are similar to Elements and Descendants. The following is the complete list of methods that have similar method signatures:

- Ancestors
- Descendants
- Elements
- ElementsAfterSelf
- ElementsBeforeSelf
- AncestorsAndSelf
- DescendantsAndSelf

Example

The following example shows the same query for XML that is in a namespace. For more information, see Working with XML Namespaces (C#).

This example uses the following XML document: Sample XML File: Typical Purchase Order in a Namespace.

```
XNamespace aw = "http://www.adventure-works.com";
XElement po = XElement.Load("PurchaseOrderInNamespace.xml");
IEnumerable<XElement> items =
    from el in po.Descendants(aw + "ProductName")
    select el;
foreach (XElement prdName in items)
    Console.WriteLine(prdName.Name + ":" + (string)prdName);
```

This code produces the following output:

```
{http://www.adventure-works.com}ProductName:Lawnmower
{http://www.adventure-works.com}ProductName:Baby Monitor
```

See also

- LINQ to XML Axes (C#)

How to: Chain Axis Method Calls (LINQ to XML) (C#)

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A common pattern that you will use in your code is to call an axis method, then call one of the extension method axes.

There are two axes with the name of `Elements` that return a collection of elements: the XContainer.Elements method and the Extensions.Elements method. You can combine these two axes to find all elements of a specified name at a given depth in the tree.

Example

This example uses XContainer.Elements and Extensions.Elements to find all `Name` elements in all `Address` elements in all `PurchaseOrder` elements.

This example uses the following XML document: Sample XML File: Multiple Purchase Orders (LINQ to XML).

```
XElement purchaseOrders = XElement.Load("PurchaseOrders.xml");
IEnumerable<XElement> names =
    from el in purchaseOrders
        .Elements("PurchaseOrder")
        .Elements("Address")
        .Elements("Name")
    select el;
foreach (XElement e in names)
    Console.WriteLine(e);
```

This example produces the following output:

```
<Name>Ellen Adams</Name>
<Name>Tai Yee</Name>
<Name>Cristian Osorio</Name>
<Name>Cristian Osorio</Name>
<Name>Jessica Arnold</Name>
<Name>Jessica Arnold</Name>
```

This works because one of the implementations of the `Elements` axis is as an extension method on IEnumerable<T> of XContainer. XElement derives from XContainer, so you can call the Extensions.Elements method on the results of a call to the XContainer.Elements method.

Example

Sometimes you want to retrieve all elements at a particular element depth when there might or might not be intervening ancestors. For example, in the following document, you might want to retrieve all the `ConfigParameter` elements that are children of the `Customer` element, but not the `ConfigParameter` that is a child of the `Root` element.

```
<Root>
  <ConfigParameter>RootConfigParameter</ConfigParameter>
  <Customer>
    <Name>Frank</Name>
    <Config>
      <ConfigParameter>FirstConfigParameter</ConfigParameter>
    </Config>
  </Customer>
  <Customer>
    <Name>Bob</Name>
    <!--This customer doesn't have a Config element-->
  </Customer>
  <Customer>
    <Name>Bill</Name>
    <Config>
      <ConfigParameter>SecondConfigParameter</ConfigParameter>
    </Config>
  </Customer>
</Root>
```

To do this, you can use the Extensions.Elements axis, as follows:

```
XElement root = XElement.Load("Irregular.xml");
IEnumerable<XElement> configParameters =
    root.Elements("Customer").Elements("Config").
    Elements("ConfigParameter");
foreach (XElement cp in configParameters)
    Console.WriteLine(cp);
```

This example produces the following output:

```
<ConfigParameter>FirstConfigParameter</ConfigParameter>
<ConfigParameter>SecondConfigParameter</ConfigParameter>
```

Example

The following example shows the same technique for XML that is in a namespace. For more information, see Working with XML Namespaces (C#).

This example uses the following XML document: Sample XML File: Multiple Purchase Orders in a Namespace.

```
XNamespace aw = "http://www.adventure-works.com";
XElement purchaseOrders = XElement.Load("PurchaseOrdersInNamespace.xml");
IEnumerable<XElement> names =
    from el in purchaseOrders
        .Elements(aw + "PurchaseOrder")
        .Elements(aw + "Address")
        .Elements(aw + "Name")
    select el;
foreach (XElement e in names)
    Console.WriteLine(e);
```

This example produces the following output:

```
<aw:Name xmlns:aw="http://www.adventure-works.com">Ellen Adams</aw:Name>
<aw:Name xmlns:aw="http://www.adventure-works.com">Tai Yee</aw:Name>
<aw:Name xmlns:aw="http://www.adventure-works.com">Cristian Osorio</aw:Name>
<aw:Name xmlns:aw="http://www.adventure-works.com">Cristian Osorio</aw:Name>
<aw:Name xmlns:aw="http://www.adventure-works.com">Jessica Arnold</aw:Name>
<aw:Name xmlns:aw="http://www.adventure-works.com">Jessica Arnold</aw:Name>
```

See also

- LINQ to XML Axes (C#)

How to: Retrieve a Single Child Element (LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic explains how to retrieve a single child element, given the name of the child element. When you know the name of the child element and that there is only one element that has this name, it can be convenient to retrieve just one element, instead of a collection.

The Element method returns the first child XElement with the specified XName.

If you want to retrieve a single child element in Visual Basic, a common approach is to use the XML property, and then retrieve the first element using array indexer notation.

Example

The following example demonstrates the use of the Element method. This example takes the XML tree named `po` and finds the first element named `Comment`.

The Visual Basic example shows using array indexer notation to retrieve a single element.

This example uses the following XML document: Sample XML File: Typical Purchase Order (LINQ to XML).

```
XElement po = XElement.Load("PurchaseOrder.xml");
XElement e = po.Element("DeliveryNotes");
Console.WriteLine(e);
```

This example produces the following output:

```
<DeliveryNotes>Please leave packages in shed by driveway.</DeliveryNotes>
```

Example

The following example shows the same code for XML that is in a namespace. For more information, see Working with XML Namespaces (C#).

This example uses the following XML document: Sample XML File: Typical Purchase Order in a Namespace.

```
XElement po = XElement.Load("PurchaseOrderInNamespace.xml");
XNamespace aw = "http://www.adventure-works.com";
XElement e = po.Element(aw + "DeliveryNotes");
Console.WriteLine(e);
```

This example produces the following output:

```
<aw:DeliveryNotes xmlns:aw="http://www.adventure-works.com">Please leave packages in shed by driveway.
</aw:DeliveryNotes>
```

See also

- LINQ to XML Axes (C#)

How to: Retrieve a Collection of Attributes (LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic introduces the Attributes method. This method retrieves the attributes of an element.

Example

The following example shows how to iterate through the collection of attributes of an element.

```
XElement val = new XElement("Value",
    new XAttribute("ID", "1243"),
    new XAttribute("Type", "int"),
    new XAttribute("ConvertableTo", "double"),
    "100");
IEnumerable<XAttribute> listOfAttributes =
    from att in val.Attributes()
    select att;
foreach (XAttribute a in listOfAttributes)
    Console.WriteLine(a);
```

This code produces the following output:

```
ID="1243"
Type="int"
ConvertableTo="double"
```

See also

- LINQ to XML Axes (C#)

How to: Retrieve a Single Attribute (LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic explains how to retrieve a single attribute of an element, given the attribute name. This is useful for writing query expressions where you want to find an element that has a particular attribute.

The Attribute method of the XElement class returns the XAttribute with the specified name.

Example

The following example uses the Attribute method.

```
XElement cust = new XElement("PhoneNumbers",
    new XElement("Phone",
        new XAttribute("type", "home"),
        "555-555-5555"),
    new XElement("Phone",
        new XAttribute("type", "work"),
        "555-555-6666")
);
IEnumerable<XElement> elList =
    from el in cust.Descendants("Phone")
    select el;
foreach (XElement el in elList)
    Console.WriteLine((string)el.Attribute("type"));
```

This example finds all the descendants in the tree named `Phone`, and then finds the attribute named `type`.

This code produces the following output:

```
home
work
```

Example

If you want to retrieve the value of the attribute, you can cast it, just as you do for with XElement objects. The following example demonstrates this.

```
XElement cust = new XElement("PhoneNumbers",
    new XElement("Phone",
        new XAttribute("type", "home"),
        "555-555-5555"),
    new XElement("Phone",
        new XAttribute("type", "work"),
        "555-555-6666")
);
IEnumerable<XElement> elList =
    from el in cust.Descendants("Phone")
    select el;
foreach (XElement el in elList)
    Console.WriteLine((string)el.Attribute("type"));
```

This code produces the following output:

```
home
work
```

LINQ to XML provides explicit cast operators for the XAttribute class to `string`, `bool`, `bool?`, `int`, `int?`, `uint`, `uint?`, `long`, `long?`, `ulong`, `ulong?`, `float`, `float?`, `double`, `double?`, `decimal`, `decimal?`, `DateTime`, `DateTime?`, `TimeSpan`, `TimeSpan?`, `GUID`, and `GUID?`.

Example

The following example shows the same code for an attribute that is in a namespace. For more information, see Working with XML Namespaces (C#).

```
XNamespace aw = "http://www.adventure-works.com";
XElement cust = new XElement(aw + "PhoneNumbers",
    new XElement(aw + "Phone",
        new XAttribute(aw + "type", "home"),
        "555-555-5555"),
    new XElement(aw + "Phone",
        new XAttribute(aw + "type", "work"),
        "555-555-6666")
);
IEnumerable<XElement> elList =
    from el in cust.Descendants(aw + "Phone")
    select el;
foreach (XElement el in elList)
    Console.WriteLine((string)el.Attribute(aw + "type"));
```

This code produces the following output:

```
home
work
```

See also

- LINQ to XML Axes (C#)

How to: Retrieve the Value of an Attribute (LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows how to obtain the value of attributes. There are two main ways: You can cast an XAttribute to the desired type; the explicit conversion operator then converts the contents of the element or attribute to the specified type. Alternatively, you can use the Value property. However, casting is generally the better approach. If you cast the attribute to a nullable type, the code is simpler to write when retrieving the value of an attribute that might or might not exist. For examples of this technique, see How to: Retrieve the Value of an Element (LINQ to XML) (C#).

Example

To retrieve the value of an attribute, you just cast the XAttribute object to your desired type.

```
XElement root = new XElement("Root",
                    new XAttribute("Attr", "abcde")
                );
Console.WriteLine(root);
string str = (string)root.Attribute("Attr");
Console.WriteLine(str);
```

This example produces the following output:

```
<Root Attr="abcde" />
abcde
```

Example

The following example shows how to retrieve the value of an attribute where the attribute is in a namespace. For more information, see Working with XML Namespaces (C#).

```
XNamespace aw = "http://www.adventure-works.com";
XElement root = new XElement(aw + "Root",
                    new XAttribute(aw + "Attr", "abcde")
                );
string str = (string)root.Attribute(aw + "Attr");
Console.WriteLine(str);
```

This example produces the following output:

```
abcde
```

See also

- LINQ to XML Axes (C#)

How to: Retrieve the Shallow Value of an Element (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows how to get the shallow value of an element. The shallow value is the value of the specific element only, as opposed to the deep value, which includes the values of all descendent elements concatenated into a single string.

When you retrieve an element value by using either casting or the XElement.Value property, you retrieve the deep value. To retrieve the shallow value, you can use the `ShallowValue` extension method, as shown in the following example. Retrieving the shallow value is useful when you want to select elements based on their content.

The following example declares an extension method that retrieves the shallow value of an element. It then uses the extension method in a query to list all elements that contain a calculated value.

Example

The following text file, Report.xml, is the source for this example.

```
<?xml version="1.0" encoding="utf-8" ?>
<Report>
  <Section>
    <Heading>
      <Column Name="CustomerId">=Customer.CustomerId.Heading</Column>
      <Column Name="Name">=Customer.Name.Heading</Column>
    </Heading>
    <Detail>
      <Column Name="CustomerId">=Customer.CustomerId</Column>
      <Column Name="Name">=Customer.Name</Column>
    </Detail>
  </Section>
</Report>
```

```
public static class MyExtensions
{
    public static string ShallowValue(this XElement xe)
    {
        return xe
               .Nodes()
               .OfType<XText>()
               .Aggregate(new StringBuilder(),
                          (s, c) => s.Append(c),
                          s => s.ToString());
    }
}

class Program
{
    static void Main(string[] args)
    {
        XElement root = XElement.Load("Report.xml");

        IEnumerable<XElement> query = from el in root.Descendants()
                                      where el.ShallowValue().StartsWith("=")
                                      select el;

        foreach (var q in query)
        {
            Console.WriteLine("{0}{1}{2}",
                q.Name.ToString().PadRight(8),
                q.Attribute("Name").ToString().PadRight(20),
                q.ShallowValue());
        }
    }
}
```

This example produces the following output:

```
Column  Name="CustomerId"   =Customer.CustomerId.Heading
Column  Name="Name"         =Customer.Name.Heading
Column  Name="CustomerId"   =Customer.CustomerId
Column  Name="Name"         =Customer.Name
```

See also

- LINQ to XML Axes (C#)

Querying XML Trees (C#)

1/23/2019 • 2 minutes to read • Edit Online

This section provides examples of LINQ to XML queries.

For more information about writing LINQ queries, see Getting Started with LINQ in C#.

After you have instantiated an XML tree, writing queries is the most effective way to extract data from the tree. Also, querying combined with functional construction enables you to generate a new XML document that has a different shape from the original document.

In This Section

TOPIC	DESCRIPTION
Basic Queries (LINQ to XML) (C#)	Provides common examples of querying XML trees.
Projections and Transformations (LINQ to XML) (C#)	Provides common examples of projecting from and transforming XML trees.
Advanced Query Techniques (LINQ to XML) (C#)	Provides query techniques that are useful in more advanced scenarios.
LINQ to XML for XPath Users (C#)	Presents a number of XPath expressions and their LINQ to XML equivalents.
Pure Functional Transformations of XML (C#)	Presents a small tutorial on writing queries in the style of functional programming.

See also

- Programming Guide (LINQ to XML) (C#)
- Getting Started with LINQ in C#

Basic Queries (LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This section provides examples of basic LINQ to XML queries.

In This Section

TOPIC	DESCRIPTION
How to: Find an Element with a Specific Attribute (C#)	Shows how to find a particular element that has an attribute that has a specific value.
How to: Find an Element with a Specific Child Element (C#)	Shows how to find a particular element that has a child element that has a specific value.
Querying an XDocument vs. Querying an XElement (C#)	Explains the differences between writing queries on an XML tree that is rooted in XElement and writing queries on an XML tree that is rooted in XDocument.
How to: Find Descendants with a Specific Element Name (C#)	Shows how to find all the descendants of an element that have a specific name. This example uses the Descendants axis.
How to: Find a Single Descendant Using the Descendants Method (C#)	Shows how to use the Descendants axis method to find a single uniquely named element.
How to: Write Queries with Complex Filtering (C#)	Shows how to write a query with a more complex filter.
How to: Filter on an Optional Element (C#)	Shows how to find nodes in an irregularly shaped tree.
How to: Find All Nodes in a Namespace (C#)	Shows how to find all nodes that are in a specific namespace.
How to: Sort Elements (C#)	Shows how to write a query that sorts its results.
How to: Sort Elements on Multiple Keys (C#)	Shows how to sort on multiple keys.
How to: Calculate Intermediate Values (C#)	Shows how to use the `Let` clause to calculate intermediate values in a LINQ to XML query.
How to: Write a Query that Finds Elements Based on Context (C#)	Shows how to select elements based on other elements in the tree.
How to: Debug Empty Query Results Sets (C#)	Shows the appropriate fix when debugging queries on XML that is in a default namespace.

See also

- Querying XML Trees (C#)

How to: Find an Element with a Specific Attribute (C#)

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This topic shows how to find an element that has an attribute that has a specific value.

Example

The example shows how to find the `Address` element that has a `Type` attribute with a value of "Billing".

This example uses the following XML document: Sample XML File: Typical Purchase Order (LINQ to XML).

```
XElement root = XElement.Load("PurchaseOrder.xml");
IEnumerable<XElement> address =
    from el in root.Elements("Address")
    where (string)el.Attribute("Type") == "Billing"
    select el;
foreach (XElement el in address)
    Console.WriteLine(el);
```

This code produces the following output:

```
<Address Type="Billing">
  <Name>Tai Yee</Name>
  <Street>8 Oak Avenue</Street>
  <City>Old Town</City>
  <State>PA</State>
  <Zip>95819</Zip>
  <Country>USA</Country>
</Address>
```

Example

The following example shows the same query for XML that is in a namespace. For more information, see Working with XML Namespaces (C#).

This example uses the following XML document: Sample XML File: Typical Purchase Order in a Namespace.

```
XElement root = XElement.Load("PurchaseOrderInNamespace.xml");
XNamespace aw = "http://www.adventure-works.com";
IEnumerable<XElement> address =
    from el in root.Elements(aw + "Address")
    where (string)el.Attribute(aw + "Type") == "Billing"
    select el;
foreach (XElement el in address)
    Console.WriteLine(el);
```

This code produces the following output:

```xml
<aw:Address aw:Type="Billing" xmlns:aw="http://www.adventure-works.com">
  <aw:Name>Tai Yee</aw:Name>
  <aw:Street>8 Oak Avenue</aw:Street>
  <aw:City>Old Town</aw:City>
  <aw:State>PA</aw:State>
  <aw:Zip>95819</aw:Zip>
  <aw:Country>USA</aw:Country>
</aw:Address>
```

See also

- Attribute
- Elements
- Basic Queries (LINQ to XML) (C#)
- Standard Query Operators Overview (C#)
- Projection Operations (C#)

How to: Find an Element with a Specific Child Element (C#)

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This topic shows how to find a particular element that has a child element with a specific value.

Example

The example finds the `Test` element that has a `CommandLine` child element with the value of "Examp2.EXE".

This example uses the following XML document: Sample XML File: Test Configuration (LINQ to XML).

```
XElement root = XElement.Load("TestConfig.xml");
IEnumerable<XElement> tests =
    from el in root.Elements("Test")
    where (string)el.Element("CommandLine") == "Examp2.EXE"
    select el;
foreach (XElement el in tests)
    Console.WriteLine((string)el.Attribute("TestId"));
```

This code produces the following output:

```
0002
0006
```

Example

The following example shows the same query for XML that is in a namespace. For more information, see Working with XML Namespaces (C#).

This example uses the following XML document: Sample XML File: Test Configuration in a Namespace.

```
XElement root = XElement.Load("TestConfigInNamespace.xml");
XNamespace ad = "http://www.adatum.com";
IEnumerable<XElement> tests =
    from el in root.Elements(ad + "Test")
    where (string)el.Element(ad + "CommandLine") == "Examp2.EXE"
    select el;
foreach (XElement el in tests)
    Console.WriteLine((string)el.Attribute("TestId"));
```

This code produces the following output:

```
0002
0006
```

See also

- Attribute
- Elements

- Basic Queries (LINQ to XML) (C#)
- Standard Query Operators Overview (C#)
- Projection Operations (C#)

Querying an XDocument vs. Querying an XElement (C#)

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When you load a document via XDocument.Load, you will notice that you have to write queries slightly differently than when you load via XElement.Load.

Comparison of XDocument.Load and XElement.Load

When you load an XML document into an XElement via XElement.Load, the XElement at the root of the XML tree contains the root element of the loaded document. However, when you load the same XML document into an XDocument via XDocument.Load, the root of the tree is an XDocument node, and the root element of the loaded document is the one allowed child XElement node of the XDocument. The LINQ to XML axes operate relative to the root node.

This first example loads an XML tree using Load. It then queries for the child elements of the root of the tree.

```
// Create a simple document and write it to a file
File.WriteAllText("Test.xml", @"<Root>
    <Child1>1</Child1>
    <Child2>2</Child2>
    <Child3>3</Child3>
</Root>");

Console.WriteLine("Querying tree loaded with XElement.Load");
Console.WriteLine("----");
XElement doc = XElement.Load("Test.xml");
IEnumerable<XElement> childList =
    from el in doc.Elements()
    select el;
foreach (XElement e in childList)
    Console.WriteLine(e);
```

As expected, this example produces the following output:

```
Querying tree loaded with XElement.Load
----
<Child1>1</Child1>
<Child2>2</Child2>
<Child3>3</Child3>
```

The following example is the same as the one above, with the exception that the XML tree is loaded into an XDocument instead of an XElement.

```
// Create a simple document and write it to a file
File.WriteAllText("Test.xml", @"<Root>
    <Child1>1</Child1>
    <Child2>2</Child2>
    <Child3>3</Child3>
</Root>");

Console.WriteLine("Querying tree loaded with XDocument.Load");
Console.WriteLine("----");
XDocument doc = XDocument.Load("Test.xml");
IEnumerable<XElement> childList =
    from el in doc.Elements()
    select el;
foreach (XElement e in childList)
    Console.WriteLine(e);
```

This example produces the following output:

```
Querying tree loaded with XDocument.Load
----
<Root>
  <Child1>1</Child1>
  <Child2>2</Child2>
  <Child3>3</Child3>
</Root>
```

Notice that the same query returned the one `Root` node instead of the three child nodes.

One approach to dealing with this is to use the Root property before accessing the axes methods, as follows:

```
// Create a simple document and write it to a file
File.WriteAllText("Test.xml", @"<Root>
    <Child1>1</Child1>
    <Child2>2</Child2>
    <Child3>3</Child3>
</Root>");

Console.WriteLine("Querying tree loaded with XDocument.Load");
Console.WriteLine("----");
XDocument doc = XDocument.Load("Test.xml");
IEnumerable<XElement> childList =
    from el in doc.Root.Elements()
    select el;
foreach (XElement e in childList)
    Console.WriteLine(e);
```

This query now performs in the same way as the query on the tree rooted in XElement. The example produces the following output:

```
Querying tree loaded with XDocument.Load
----
<Child1>1</Child1>
<Child2>2</Child2>
<Child3>3</Child3>
```

See also

- Basic Queries (LINQ to XML) (C#)

How to: Find Descendants with a Specific Element Name (C#)

1/23/2019 • 2 minutes to read • Edit Online

Sometimes you want to find all descendants with a particular name. You could write code to iterate through all of the descendants, but it is easier to use the Descendants axis.

Example

The following example shows how to find descendants based on the element name.

```
XElement root = XElement.Parse(@"<root>
  <para>
    <r>
      <t>Some text </t>
    </r>
    <n>
      <r>
        <t>that is broken up into </t>
      </r>
    </n>
    <n>
      <r>
        <t>multiple segments.</t>
      </r>
    </n>
  </para>
</root>");
IEnumerable<string> textSegs =
    from seg in root.Descendants("t")
    select (string)seg;

string str = textSegs.Aggregate(new StringBuilder(),
    (sb, i) => sb.Append(i),
    sp => sp.ToString()
);

Console.WriteLine(str);
```

This code produces the following output:

```
Some text that is broken up into multiple segments.
```

Example

The following example shows the same query for XML that is in a namespace. For more information, see Working with XML Namespaces (C#).

```
XElement root = XElement.Parse(@"<root xmlns='http://www.adatum.com'>
  <para>
    <r>
      <t>Some text </t>
    </r>
    <n>
      <r>
        <t>that is broken up into </t>
      </r>
    </n>
    <n>
      <r>
        <t>multiple segments.</t>
      </r>
    </n>
  </para>
</root>");
XNamespace ad = "http://www.adatum.com";
IEnumerable<string> textSegs =
    from seg in root.Descendants(ad + "t")
    select (string)seg;

string str = textSegs.Aggregate(new StringBuilder(),
    (sb, i) => sb.Append(i),
    sp => sp.ToString()
);

Console.WriteLine(str);
```

This code produces the following output:

```
Some text that is broken up into multiple segments.
```

See also

- Descendants
- Basic Queries (LINQ to XML) (C#)

How to: Find a Single Descendant Using the Descendants Method (C#)

1/23/2019 • 2 minutes to read • Edit Online

You can use the Descendants axis method to quickly write code to find a single uniquely named element. This technique is especially useful when you want to find a particular descendant with a specific name. You could write the code to navigate to the desired element, but it is often faster and easier to write the code using the Descendants axis.

Example

This example uses the First standard query operator.

```
XElement root = XElement.Parse(@"<Root>
  <Child1>
    <GrandChild1>GC1 Value</GrandChild1>
  </Child1>
  <Child2>
    <GrandChild2>GC2 Value</GrandChild2>
  </Child2>
  <Child3>
    <GrandChild3>GC3 Value</GrandChild3>
  </Child3>
  <Child4>
    <GrandChild4>GC4 Value</GrandChild4>
  </Child4>
</Root>");
string grandChild3 = (string)
    (from el in root.Descendants("GrandChild3")
    select el).First();
Console.WriteLine(grandChild3);
```

This code produces the following output:

```
GC3 Value
```

Example

The following example shows the same query for XML that is in a namespace. For more information, see Working with XML Namespaces (C#).

```
XElement root = XElement.Parse(@"<aw:Root xmlns:aw='http://www.adventure-works.com'>
  <aw:Child1>
    <aw:GrandChild1>GC1 Value</aw:GrandChild1>
  </aw:Child1>
  <aw:Child2>
    <aw:GrandChild2>GC2 Value</aw:GrandChild2>
  </aw:Child2>
  <aw:Child3>
    <aw:GrandChild3>GC3 Value</aw:GrandChild3>
  </aw:Child3>
  <aw:Child4>
    <aw:GrandChild4>GC4 Value</aw:GrandChild4>
  </aw:Child4>
</aw:Root>");
XNamespace aw = "http://www.adventure-works.com";
string grandChild3 = (string)
    (from el in root.Descendants(aw + "GrandChild3")
     select el).First();
Console.WriteLine(grandChild3);
```

This code produces the following output:

```
GC3 Value
```

See also

- Basic Queries (LINQ to XML) (C#)

How to: Write Queries with Complex Filtering (C#)

1/23/2019 • 2 minutes to read • Edit Online

Sometimes you want to write LINQ to XML queries with complex filters. For example, you might have to find all elements that have a child element with a particular name and value. This topic gives an example of writing a query with complex filtering.

Example

This example shows how to find all `PurchaseOrder` elements that have a child `Address` element that has a `Type` attribute equal to "Shipping" and a child `State` element equal to "NY". It uses a nested query in the `Where` clause, and the `Any` operator returns `true` if the collection has any elements in it. For information about using method-based query syntax, see Query Syntax and Method Syntax in LINQ.

This example uses the following XML document: Sample XML File: Multiple Purchase Orders (LINQ to XML).

For more information about the `Any` operator, see Quantifier Operations (C#).

```
XElement root = XElement.Load("PurchaseOrders.xml");
IEnumerable<XElement> purchaseOrders =
    from el in root.Elements("PurchaseOrder")
    where
        (from add in el.Elements("Address")
        where
            (string)add.Attribute("Type") == "Shipping" &&
            (string)add.Element("State") == "NY"
        select add)
        .Any()
    select el;
foreach (XElement el in purchaseOrders)
    Console.WriteLine((string)el.Attribute("PurchaseOrderNumber"));
```

This code produces the following output:

```
99505
```

Example

The following example shows the same query for XML that is in a namespace. For more information, see Working with XML Namespaces (C#).

This example uses the following XML document: Sample XML File: Multiple Purchase Orders in a Namespace.

```
XElement root = XElement.Load("PurchaseOrdersInNamespace.xml");
XNamespace aw = "http://www.adventure-works.com";
IEnumerable<XElement> purchaseOrders =
    from el in root.Elements(aw + "PurchaseOrder")
    where
        (from add in el.Elements(aw + "Address")
         where
             (string)add.Attribute(aw + "Type") == "Shipping" &&
             (string)add.Element(aw + "State") == "NY"
         select add)
        .Any()
    select el;
foreach (XElement el in purchaseOrders)
    Console.WriteLine((string)el.Attribute(aw + "PurchaseOrderNumber"));
```

This code produces the following output:

```
99505
```

See also

- Attribute
- Elements
- Basic Queries (LINQ to XML) (C#)
- Projection Operations (C#)
- Quantifier Operations (C#)

How to: Filter on an Optional Element (C#)

1/23/2019 • 2 minutes to read • Edit Online

Sometimes you want to filter for an element even though you are not sure it exists in your XML document. The search should be executed so that if the particular element does not have the child element, you do not trigger a null reference exception by filtering for it. In the following example, the `Child5` element does not have a `Type` child element, but the query still executes correctly.

Example

This example uses the Elements extension method.

```
XElement root = XElement.Parse(@"<Root>
  <Child1>
    <Text>Child One Text</Text>
    <Type Value=""Yes""/>
  </Child1>
  <Child2>
    <Text>Child Two Text</Text>
    <Type Value=""Yes""/>
  </Child2>
  <Child3>
    <Text>Child Three Text</Text>
    <Type Value=""No""/>
  </Child3>
  <Child4>
    <Text>Child Four Text</Text>
    <Type Value=""Yes""/>
  </Child4>
  <Child5>
    <Text>Child Five Text</Text>
  </Child5>
</Root>");
var cList =
    from typeElement in root.Elements().Elements("Type")
    where (string)typeElement.Attribute("Value") == "Yes"
    select (string)typeElement.Parent.Element("Text");
foreach(string str in cList)
    Console.WriteLine(str);
```

This code produces the following output:

```
Child One Text
Child Two Text
Child Four Text
```

Example

The following example shows the same query for XML that is in a namespace. For more information, see Working with XML Namespaces (C#).

```
XElement root = XElement.Parse(@"<Root xmlns='http://www.adatum.com'>
  <Child1>
    <Text>Child One Text</Text>
    <Type Value=""Yes""/>
  </Child1>
  <Child2>
    <Text>Child Two Text</Text>
    <Type Value=""Yes""/>
  </Child2>
  <Child3>
    <Text>Child Three Text</Text>
    <Type Value=""No""/>
  </Child3>
  <Child4>
    <Text>Child Four Text</Text>
    <Type Value=""Yes""/>
  </Child4>
  <Child5>
    <Text>Child Five Text</Text>
  </Child5>
</Root>");
XNamespace ad = "http://www.adatum.com";
var cList =
    from typeElement in root.Elements().Elements(ad + "Type")
    where (string)typeElement.Attribute("Value") == "Yes"
    select (string)typeElement.Parent.Element(ad + "Text");
foreach (string str in cList)
    Console.WriteLine(str);
```

This code produces the following output:

```
Child One Text
Child Two Text
Child Four Text
```

See also

- XElement.Attribute
- XContainer.Elements
- Extensions.Elements
- Basic Queries (LINQ to XML) (C#)
- Standard Query Operators Overview (C#)
- Projection Operations (C#)

How to: Find All Nodes in a Namespace (C#)

1/23/2019 • 2 minutes to read • Edit Online

You can filter on the namespace of each element or attribute to find all nodes in that particular namespace.

Example

The following example creates an XML tree with two namespaces. It then iterates through the tree and prints the names of all the elements and attributes in one of those namespaces.

```
string markup = @"<aw:Root xmlns:aw='http://www.adventure-works.com' xmlns:fc='www.fourthcoffee.com'>
  <fc:Child1>abc</fc:Child1>
  <fc:Child2>def</fc:Child2>
  <aw:Child3>ghi</aw:Child3>
  <fc:Child4>
    <fc:GrandChild1>jkl</fc:GrandChild1>
    <aw:GrandChild2>mno</aw:GrandChild2>
  </fc:Child4>
</aw:Root>";
XElement xmlTree = XElement.Parse(markup);
Console.WriteLine("Nodes in the http://www.adventure-works.com namespace");
IEnumerable<XElement> awElements =
    from el in xmlTree.Descendants()
    where el.Name.Namespace == "http://www.adventure-works.com"
    select el;
foreach (XElement el in awElements)
    Console.WriteLine(el.Name.ToString());
```

This code produces the following output:

```
Nodes in the http://www.adventure-works.com namespace
{http://www.adventure-works.com}Child3
{http://www.adventure-works.com}GrandChild2
```

Example

The XML file accessed by the following query contains purchase orders in two different namespaces. The query creates a new tree with just the elements in one of the namespaces.

This example uses the following XML document: Sample XML File: Consolidated Purchase Orders.

```
XDocument cpo = XDocument.Load("ConsolidatedPurchaseOrders.xml");
XNamespace aw = "http://www.adventure-works.com";
XElement newTree = new XElement("Root",
    from el in cpo.Root.Elements()
    where el.Name.Namespace == aw
    select el
);
Console.WriteLine(newTree);
```

This code produces the following output:

```xml
<Root>
  <aw:PurchaseOrder PONumber="11223" Date="2000-01-15" xmlns:aw="http://www.adventure-works.com">
    <aw:ShippingAddress>
      <aw:Name>Chris Preston</aw:Name>
      <aw:Street>123 Main St.</aw:Street>
      <aw:City>Seattle</aw:City>
      <aw:State>WA</aw:State>
      <aw:Zip>98113</aw:Zip>
      <aw:Country>USA</aw:Country>
    </aw:ShippingAddress>
    <aw:BillingAddress>
      <aw:Name>Chris Preston</aw:Name>
      <aw:Street>123 Main St.</aw:Street>
      <aw:City>Seattle</aw:City>
      <aw:State>WA</aw:State>
      <aw:Zip>98113</aw:Zip>
      <aw:Country>USA</aw:Country>
    </aw:BillingAddress>
    <aw:DeliveryInstructions>Ship only complete order.</aw:DeliveryInstructions>
    <aw:Item PartNum="LIT-01">
      <aw:ProductID>Litware Networking Card</aw:ProductID>
      <aw:Qty>1</aw:Qty>
      <aw:Price>20.99</aw:Price>
    </aw:Item>
    <aw:Item PartNum="LIT-25">
      <aw:ProductID>Litware 17in LCD Monitor</aw:ProductID>
      <aw:Qty>1</aw:Qty>
      <aw:Price>199.99</aw:Price>
    </aw:Item>
  </aw:PurchaseOrder>
</Root>
```

See also

- Basic Queries (LINQ to XML) (C#)

How to: Sort Elements (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example shows how to write a query that sorts its results.

Example

This example uses the following XML document: Sample XML File: Numerical Data (LINQ to XML).

```
XElement root = XElement.Load("Data.xml");
IEnumerable<decimal> prices =
    from el in root.Elements("Data")
    let price = (decimal)el.Element("Price")
    orderby price
    select price;
foreach (decimal el in prices)
    Console.WriteLine(el);
```

This code produces the following output:

```
0.99
4.95
6.99
24.50
29.00
66.00
89.99
```

Example

The following example shows the same query for XML that is in a namespace. For more information, see Working with XML Namespaces (C#).

This example uses the following XML document: Sample XML File: Numerical Data in a Namespace.

```
XElement root = XElement.Load("DataInNamespace.xml");
XNamespace aw = "http://www.adatum.com";
IEnumerable<decimal> prices =
    from el in root.Elements(aw + "Data")
    let price = (decimal)el.Element(aw + "Price")
    orderby price
    select price;
foreach (decimal el in prices)
    Console.WriteLine(el);
```

This code produces the following output:

```
0.99
4.95
6.99
24.50
29.00
66.00
89.99
```

See also

- Sorting Data (C#)
- Basic Queries (LINQ to XML) (C#)

How to: Sort Elements on Multiple Keys (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows how to sort on multiple keys.

Example

In this example, the results are ordered first by the shipping postal code, then by the order date.

This example uses the following XML document: Sample XML File: Customers and Orders (LINQ to XML).

```
XElement co = XElement.Load("CustomersOrders.xml");
var sortedElements =
    from c in co.Element("Orders").Elements("Order")
    orderby (string)c.Element("ShipInfo").Element("ShipPostalCode"),
            (DateTime)c.Element("OrderDate")
    select new {
        CustomerID = (string)c.Element("CustomerID"),
        EmployeeID = (string)c.Element("EmployeeID"),
        ShipPostalCode = (string)c.Element("ShipInfo").Element("ShipPostalCode"),
        OrderDate = (DateTime)c.Element("OrderDate")
    };
foreach (var r in sortedElements)
    Console.WriteLine("CustomerID:{0} EmployeeID:{1} ShipPostalCode:{2} OrderDate:{3:d}",
        r.CustomerID, r.EmployeeID, r.ShipPostalCode, r.OrderDate);
```

This code produces the following output:

```
CustomerID:LETSS EmployeeID:1 ShipPostalCode:94117 OrderDate:6/25/1997
CustomerID:LETSS EmployeeID:8 ShipPostalCode:94117 OrderDate:10/27/1997
CustomerID:LETSS EmployeeID:6 ShipPostalCode:94117 OrderDate:11/10/1997
CustomerID:LETSS EmployeeID:4 ShipPostalCode:94117 OrderDate:2/12/1998
CustomerID:GREAL EmployeeID:6 ShipPostalCode:97403 OrderDate:5/6/1997
CustomerID:GREAL EmployeeID:8 ShipPostalCode:97403 OrderDate:7/4/1997
CustomerID:GREAL EmployeeID:1 ShipPostalCode:97403 OrderDate:7/31/1997
CustomerID:GREAL EmployeeID:4 ShipPostalCode:97403 OrderDate:7/31/1997
CustomerID:GREAL EmployeeID:6 ShipPostalCode:97403 OrderDate:9/4/1997
CustomerID:GREAL EmployeeID:3 ShipPostalCode:97403 OrderDate:9/25/1997
CustomerID:GREAL EmployeeID:4 ShipPostalCode:97403 OrderDate:1/6/1998
CustomerID:GREAL EmployeeID:3 ShipPostalCode:97403 OrderDate:3/9/1998
CustomerID:GREAL EmployeeID:3 ShipPostalCode:97403 OrderDate:4/7/1998
CustomerID:GREAL EmployeeID:4 ShipPostalCode:97403 OrderDate:4/22/1998
CustomerID:GREAL EmployeeID:4 ShipPostalCode:97403 OrderDate:4/30/1998
CustomerID:HUNGC EmployeeID:3 ShipPostalCode:97827 OrderDate:12/6/1996
CustomerID:HUNGC EmployeeID:1 ShipPostalCode:97827 OrderDate:12/25/1996
CustomerID:HUNGC EmployeeID:3 ShipPostalCode:97827 OrderDate:1/15/1997
CustomerID:HUNGC EmployeeID:4 ShipPostalCode:97827 OrderDate:7/16/1997
CustomerID:HUNGC EmployeeID:8 ShipPostalCode:97827 OrderDate:9/8/1997
CustomerID:LAZYK EmployeeID:1 ShipPostalCode:99362 OrderDate:3/21/1997
CustomerID:LAZYK EmployeeID:8 ShipPostalCode:99362 OrderDate:5/22/1997
```

Example

The following example shows the same query for XML that is in a namespace. For more information, see Working with XML Namespaces (C#).

This example uses the following XML document: Sample XML File: Customers and Orders in a Namespace.

```
XElement co = XElement.Load("CustomersOrdersInNamespace.xml");
XNamespace aw = "http://www.adventure-works.com";
var sortedElements =
    from c in co.Element(aw + "Orders").Elements(aw + "Order")
    orderby (string)c.Element(aw + "ShipInfo").Element(aw + "ShipPostalCode"),
            (DateTime)c.Element(aw + "OrderDate")
    select new
    {
        CustomerID = (string)c.Element(aw + "CustomerID"),
        EmployeeID = (string)c.Element(aw + "EmployeeID"),
        ShipPostalCode = (string)c.Element(aw + "ShipInfo").Element(aw + "ShipPostalCode"),
        OrderDate = (DateTime)c.Element(aw + "OrderDate")
    };
foreach (var r in sortedElements)
    Console.WriteLine("CustomerID:{0} EmployeeID:{1} ShipPostalCode:{2} OrderDate:{3:d}",
        r.CustomerID, r.EmployeeID, r.ShipPostalCode, r.OrderDate);
```

This code produces the following output:

```
CustomerID:LETSS EmployeeID:1 ShipPostalCode:94117 OrderDate:6/25/1997
CustomerID:LETSS EmployeeID:8 ShipPostalCode:94117 OrderDate:10/27/1997
CustomerID:LETSS EmployeeID:6 ShipPostalCode:94117 OrderDate:11/10/1997
CustomerID:LETSS EmployeeID:4 ShipPostalCode:94117 OrderDate:2/12/1998
CustomerID:GREAL EmployeeID:6 ShipPostalCode:97403 OrderDate:5/6/1997
CustomerID:GREAL EmployeeID:8 ShipPostalCode:97403 OrderDate:7/4/1997
CustomerID:GREAL EmployeeID:1 ShipPostalCode:97403 OrderDate:7/31/1997
CustomerID:GREAL EmployeeID:4 ShipPostalCode:97403 OrderDate:7/31/1997
CustomerID:GREAL EmployeeID:6 ShipPostalCode:97403 OrderDate:9/4/1997
CustomerID:GREAL EmployeeID:3 ShipPostalCode:97403 OrderDate:9/25/1997
CustomerID:GREAL EmployeeID:4 ShipPostalCode:97403 OrderDate:1/6/1998
CustomerID:GREAL EmployeeID:3 ShipPostalCode:97403 OrderDate:3/9/1998
CustomerID:GREAL EmployeeID:3 ShipPostalCode:97403 OrderDate:4/7/1998
CustomerID:GREAL EmployeeID:4 ShipPostalCode:97403 OrderDate:4/22/1998
CustomerID:GREAL EmployeeID:4 ShipPostalCode:97403 OrderDate:4/30/1998
CustomerID:HUNGC EmployeeID:3 ShipPostalCode:97827 OrderDate:12/6/1996
CustomerID:HUNGC EmployeeID:1 ShipPostalCode:97827 OrderDate:12/25/1996
CustomerID:HUNGC EmployeeID:3 ShipPostalCode:97827 OrderDate:1/15/1997
CustomerID:HUNGC EmployeeID:4 ShipPostalCode:97827 OrderDate:7/16/1997
CustomerID:HUNGC EmployeeID:8 ShipPostalCode:97827 OrderDate:9/8/1997
CustomerID:LAZYK EmployeeID:1 ShipPostalCode:99362 OrderDate:3/21/1997
CustomerID:LAZYK EmployeeID:8 ShipPostalCode:99362 OrderDate:5/22/1997
```

See also

- Basic Queries (LINQ to XML) (C#)

How to: Calculate Intermediate Values (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example shows how to calculate intermediate values that can be used in sorting, filtering, and selecting.

Example

The following example uses the `Let` clause.

This example uses the following XML document: Sample XML File: Numerical Data (LINQ to XML).

```
XElement root = XElement.Load("Data.xml");
IEnumerable<decimal> extensions =
    from el in root.Elements("Data")
    let extension = (decimal)el.Element("Quantity") * (decimal)el.Element("Price")
    where extension >= 25
    orderby extension
    select extension;
foreach (decimal ex in extensions)
    Console.WriteLine(ex);
```

This code produces the following output:

```
55.92
73.50
89.99
198.00
435.00
```

Example

The following example shows the same query for XML that is in a namespace. For more information, see Working with XML Namespaces (C#).

This example uses the following XML document: Sample XML File: Numerical Data in a Namespace.

```
XElement root = XElement.Load("DataInNamespace.xml");
XNamespace ad = "http://www.adatum.com";
IEnumerable<decimal> extensions =
    from el in root.Elements(ad + "Data")
    let extension = (decimal)el.Element(ad + "Quantity") * (decimal)el.Element(ad + "Price")
    where extension >= 25
    orderby extension
    select extension;
foreach (decimal ex in extensions)
    Console.WriteLine(ex);
```

This code produces the following output:

```
55.92
73.50
89.99
198.00
435.00
```

See also

- Basic Queries (LINQ to XML) (C#)

How to: Write a Query that Finds Elements Based on Context (C#)

1/23/2019 • 2 minutes to read • Edit Online

Sometimes you might have to write a query that selects elements based on their context. You might want to filter based on preceding or following sibling elements. You might want to filter based on child or ancestor elements.

You can do this by writing a query and using the results of the query in the `where` clause. If you have to first test against null, and then test the value, it is more convenient to do the query in a `let` clause, and then use the results in the `where` clause.

Example

The following example selects all `p` elements that are immediately followed by a `ul` element.

```
XElement doc = XElement.Parse(@"<Root>
    <p id=""1""/>
    <ul>abc</ul>
    <Child>
        <p id=""2""/>
        <notul/>
        <p id=""3""/>
        <ul>def</ul>
        <p id=""4""/>
    </Child>
    <Child>
        <p id=""5""/>
        <notul/>
        <p id=""6""/>
        <ul>abc</ul>
        <p id=""7""/>
    </Child>
</Root>");

IEnumerable<XElement> items =
    from e in doc.Descendants("p")
    let z = e.ElementsAfterSelf().FirstOrDefault()
    where z != null && z.Name.LocalName == "ul"
    select e;

foreach (XElement e in items)
    Console.WriteLine("id = {0}", (string)e.Attribute("id"));
```

This code produces the following output:

```
id = 1
id = 3
id = 6
```

Example

The following example shows the same query for XML that is in a namespace. For more information, see Working with XML Namespaces (C#).

```
XElement doc = XElement.Parse(@"<Root xmlns='http://www.adatum.com'>
    <p id=""1""/>
    <ul>abc</ul>
    <Child>
        <p id=""2""/>
        <notul/>
        <p id=""3""/>
        <ul>def</ul>
        <p id=""4""/>
    </Child>
    <Child>
        <p id=""5""/>
        <notul/>
        <p id=""6""/>
        <ul>abc</ul>
        <p id=""7""/>
    </Child>
</Root>");

XNamespace ad = "http://www.adatum.com";

IEnumerable<XElement> items =
    from e in doc.Descendants(ad + "p")
    let z = e.ElementsAfterSelf().FirstOrDefault()
    where z != null && z.Name == ad.GetName("ul")
    select e;

foreach (XElement e in items)
    Console.WriteLine("id = {0}", (string)e.Attribute("id"));
```

This code produces the following output:

```
id = 1
id = 3
id = 6
```

See also

- Parse
- Descendants
- ElementsAfterSelf
- FirstOrDefault
- Basic Queries (LINQ to XML) (C#)

How to: Debug Empty Query Results Sets (C#)

1/23/2019 • 2 minutes to read • Edit Online

One of the most common problems when querying XML trees is that if the XML tree has a default namespace, the developer sometimes writes the query as though the XML were not in a namespace.

The first set of examples in this topic shows a typical way that XML in a default namespace is loaded, and is queried improperly.

The second set of examples show the necessary corrections so that you can query XML in a namespace.

For more information, see Working with XML Namespaces (C#).

Example

This example shows creation of XML in a namespace, and a query that returns an empty result set.

```
XElement root = XElement.Parse(
@"<Root xmlns='http://www.adventure-works.com'>
    <Child>1</Child>
    <Child>2</Child>
    <Child>3</Child>
    <AnotherChild>4</AnotherChild>
    <AnotherChild>5</AnotherChild>
    <AnotherChild>6</AnotherChild>
</Root>");
IEnumerable<XElement> c1 =
    from el in root.Elements("Child")
    select el;
Console.WriteLine("Result set follows:");
foreach (XElement el in c1)
    Console.WriteLine((int)el);
Console.WriteLine("End of result set");
```

This example produces the following result:

```
Result set follows:
End of result set
```

Example

This example shows creation of XML in a namespace, and a query that is coded properly.

The solution is to declare and initialize an XNamespace object, and to use it when specifying XName objects. In this case, the argument to the Elements method is an XName object.

```
XElement root = XElement.Parse(
@"<Root xmlns='http://www.adventure-works.com'>
    <Child>1</Child>
    <Child>2</Child>
    <Child>3</Child>
    <AnotherChild>4</AnotherChild>
    <AnotherChild>5</AnotherChild>
    <AnotherChild>6</AnotherChild>
</Root>");
XNamespace aw = "http://www.adventure-works.com";
IEnumerable<XElement> c1 =
    from el in root.Elements(aw + "Child")
    select el;
Console.WriteLine("Result set follows:");
foreach (XElement el in c1)
    Console.WriteLine((int)el);
Console.WriteLine("End of result set");
```

This example produces the following result:

```
Result set follows:
1
2
3
End of result set
```

See also

- Basic Queries (LINQ to XML) (C#)

Projections and Transformations (LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This section provides examples of LINQ to XML projections and transformations.

In This Section

TOPIC	DESCRIPTION
How to: Work with Dictionaries Using LINQ to XML (C#)	Shows how to transform dictionaries to XML, and how to transform XML into dictionaries.
How to: Transform the Shape of an XML Tree (C#)	Shows how to transform the shape of an XML document.
How to: Control the Type of a Projection (C#)	Shows how to control the type of a LINQ to XML query.
How to: Project a New Type (LINQ to XML) (C#)	Shows how to project a collection of a user-defined type from a LINQ to XML query.
How to: Project an Object Graph (C#)	Shows how to project a more complex object graph from a LINQ to XML query.
How to: Project an Anonymous Type (C#)	Shows how to project a collection of anonymous objects from a LINQ to XML query.
How to: Generate Text Files from XML (C#)	Shows how to transform an XML file to a non-XML text file.
How to: Generate XML from CSV Files (C#)	Shows how to use LINQ to parse a CSV file and generate XML from it.

See also

- Querying XML Trees (C#)

How to: Work with Dictionaries Using LINQ to XML (C#)

1/23/2019 • 2 minutes to read • Edit Online

It is often convenient to convert varieties of data structures to XML, and XML back to other data structures. This topic shows a specific implementation of this general approach by converting a Dictionary<TKey,TValue> to XML and back.

Example

This example uses a form of functional construction in which a query projects new XElement objects, and the resulting collection is passed as an argument to the constructor of the Root XElement object.

```
Dictionary<string, string> dict = new Dictionary<string, string>();
dict.Add("Child1", "Value1");
dict.Add("Child2", "Value2");
dict.Add("Child3", "Value3");
dict.Add("Child4", "Value4");
XElement root = new XElement("Root",
    from keyValue in dict
    select new XElement(keyValue.Key, keyValue.Value)
);
Console.WriteLine(root);
```

This code produces the following output:

```
<Root>
  <Child1>Value1</Child1>
  <Child2>Value2</Child2>
  <Child3>Value3</Child3>
  <Child4>Value4</Child4>
</Root>
```

Example

The following code creates a dictionary from XML.

```
XElement root = new XElement("Root",
    new XElement("Child1", "Value1"),
    new XElement("Child2", "Value2"),
    new XElement("Child3", "Value3"),
    new XElement("Child4", "Value4")
);

Dictionary<string, string> dict = new Dictionary<string, string>();
foreach (XElement el in root.Elements())
    dict.Add(el.Name.LocalName, el.Value);
foreach (string str in dict.Keys)
    Console.WriteLine("{0}:{1}", str, dict[str]);
```

This code produces the following output:

```
Child1:Value1
Child2:Value2
Child3:Value3
Child4:Value4
```

See also

- Projections and Transformations (LINQ to XML) (C#)

How to: Transform the Shape of an XML Tree (C#)

1/23/2019 • 2 minutes to read • Edit Online

The *shape* of an XML document refers to its element names, attribute names, and the characteristics of its hierarchy.

Sometimes you will have to change the shape of an XML document. For example, you might have to send an existing XML document to another system that requires different element and attribute names. You could go through the document, deleting and renaming elements as required, but using functional construction results in more readable and maintainable code. For more information about functional construction, see Functional Construction (LINQ to XML) (C#).

The first example changes the organization of the XML document. It moves complex elements from one location in the tree to another.

The second example in this topic creates an XML document with a different shape than the source document. It changes the casing of the element names, renames some elements, and leaves some elements from the source tree out of the transformed tree.

Example

The following code changes the shape of an XML file using embedded query expressions.

The source XML document in this example contains a `Customers` element under the `Root` element that contains all customers. It also contains an `Orders` element under the `Root` element that contains all orders. This example creates a new XML tree in which the orders for each customer are contained in an `Orders` element within the `Customer` element. The original document also contains a `CustomerID` element in the `Order` element; this element will be removed from the re-shaped document.

This example uses the following XML document: Sample XML File: Customers and Orders (LINQ to XML).

```
XElement co = XElement.Load("CustomersOrders.xml");
XElement newCustOrd =
    new XElement("Root",
        from cust in co.Element("Customers").Elements("Customer")
        select new XElement("Customer",
            cust.Attributes(),
            cust.Elements(),
            new XElement("Orders",
                from ord in co.Element("Orders").Elements("Order")
                where (string)ord.Element("CustomerID") == (string)cust.Attribute("CustomerID")
                select new XElement("Order",
                    ord.Attributes(),
                    ord.Element("EmployeeID"),
                    ord.Element("OrderDate"),
                    ord.Element("RequiredDate"),
                    ord.Element("ShipInfo")
                )
            )
        )
    );
Console.WriteLine(newCustOrd);
```

This code produces the following output:

```xml
<Root>
  <Customer CustomerID="GREAL">
    <CompanyName>Great Lakes Food Market</CompanyName>
    <ContactName>Howard Snyder</ContactName>
    <ContactTitle>Marketing Manager</ContactTitle>
    <Phone>(503) 555-7555</Phone>
    <FullAddress>
      <Address>2732 Baker Blvd.</Address>
      <City>Eugene</City>
      <Region>OR</Region>
      <PostalCode>97403</PostalCode>
      <Country>USA</Country>
    </FullAddress>
    <Orders />
  </Customer>
  <Customer CustomerID="HUNGC">
    <CompanyName>Hungry Coyote Import Store</CompanyName>
    <ContactName>Yoshi Latimer</ContactName>
    <ContactTitle>Sales Representative</ContactTitle>
    <Phone>(503) 555-6874</Phone>
    <Fax>(503) 555-2376</Fax>
    <FullAddress>
      <Address>City Center Plaza 516 Main St.</Address>
      <City>Elgin</City>
      <Region>OR</Region>
      <PostalCode>97827</PostalCode>
      <Country>USA</Country>
    </FullAddress>
    <Orders />
  </Customer>
  . . .
```

Example

This example renames some elements and converts some attributes to elements.

The code calls `ConvertAddress`, which returns a list of XElement objects. The argument to the method is a query that determines the `Address` complex element where the `Type` attribute has a value of `"Shipping"`.

This example uses the following XML document: Sample XML File: Typical Purchase Order (LINQ to XML).

```
static IEnumerable<XElement> ConvertAddress(XElement add)
{
    List<XElement> fragment = new List<XElement>() {
        new XElement("NAME", (string)add.Element("Name")),
        new XElement("STREET", (string)add.Element("Street")),
        new XElement("CITY", (string)add.Element("City")),
        new XElement("ST", (string)add.Element("State")),
        new XElement("POSTALCODE", (string)add.Element("Zip")),
        new XElement("COUNTRY", (string)add.Element("Country"))
    };
    return fragment;
}

static void Main(string[] args)
{
    XElement po = XElement.Load("PurchaseOrder.xml");
    XElement newPo = new XElement("PO",
        new XElement("ID", (string)po.Attribute("PurchaseOrderNumber")),
        new XElement("DATE", (DateTime)po.Attribute("OrderDate")),
        ConvertAddress(
            (from el in po.Elements("Address")
            where (string)el.Attribute("Type") == "Shipping"
            select el)
            .First()
        )
    );
    Console.WriteLine(newPo);
}
```

This code produces the following output:

```
<PO>
  <ID>99503</ID>
  <DATE>1999-10-20T00:00:00</DATE>
  <NAME>Ellen Adams</NAME>
  <STREET>123 Maple Street</STREET>
  <CITY>Mill Valley</CITY>
  <ST>CA</ST>
  <POSTALCODE>10999</POSTALCODE>
  <COUNTRY>USA</COUNTRY>
</PO>
```

See also

- Projections and Transformations (LINQ to XML) (C#)

How to: Control the Type of a Projection (C#)

1/23/2019 • 2 minutes to read • Edit Online

Projection is the process of taking one set of data, filtering it, changing its shape, and even changing its type. Most query expressions perform projections. Most of the query expressions shown in this section evaluate to IEnumerable<T> of XElement, but you can control the type of the projection to create collections of other types. This topic shows how to do this.

Example

The following example defines a new type, `Customer`. The query expression then instantiates new `Customer` objects in the `Select` clause. This causes the type of the query expression to be IEnumerable<T> of `Customer`.

This example uses the following XML document: Sample XML File: Customers and Orders (LINQ to XML).

```
public class Customer
{
    private string customerID;
    public string CustomerID{ get{return customerID;} set{customerID = value;}}

    private string companyName;
    public string CompanyName{ get{return companyName;} set{companyName = value;}}

    private string contactName;
    public string ContactName { get{return contactName;} set{contactName = value;}}

    public Customer(string customerID, string companyName, string contactName)
    {
        CustomerID = customerID;
        CompanyName = companyName;
        ContactName = contactName;
    }

    public override string ToString()
    {
        return $"{this.customerID}:{this.companyName}:{this.contactName}";
    }
}

class Program
{
    static void Main(string[] args)
    {
        XElement custOrd = XElement.Load("CustomersOrders.xml");
        IEnumerable<Customer> custList =
            from el in custOrd.Element("Customers").Elements("Customer")
            select new Customer(
                (string)el.Attribute("CustomerID"),
                (string)el.Element("CompanyName"),
                (string)el.Element("ContactName")
            );
        foreach (Customer cust in custList)
            Console.WriteLine(cust);
    }
}
```

This code produces the following output:

```
GREAL:Great Lakes Food Market:Howard Snyder
HUNGC:Hungry Coyote Import Store:Yoshi Latimer
LAZYK:Lazy K Kountry Store:John Steel
LETSS:Let's Stop N Shop:Jaime Yorres
```

See also

- Select
- Projections and Transformations (LINQ to XML) (C#)

How to: Project a New Type (LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

Other examples in this section have shown queries that return results as IEnumerable<T> of XElement, IEnumerable<T> of `string`, and IEnumerable<T> of `int`. These are common result types, but they are not appropriate for every scenario. In many cases you will want your queries to return an IEnumerable<T> of some other type.

Example

This example shows how to instantiate objects in the `select` clause. The code first defines a new class with a constructor, and then modifies the `select` statement so that the expression is a new instance of the new class.

This example uses the following XML document: Sample XML File: Typical Purchase Order (LINQ to XML).

```
class NameQty {
    public string name;
    public int qty;
    public NameQty(string n, int q)
    {
        name = n;
        qty = q;
    }
};

class Program {
    public static void Main() {
        XElement po = XElement.Load("PurchaseOrder.xml");

        IEnumerable<NameQty> nqList =
            from n in po.Descendants("Item")
            select new NameQty(
                    (string)n.Element("ProductName"),
                    (int)n.Element("Quantity")
                );

        foreach (NameQty n in nqList)
            Console.WriteLine(n.name + ":" + n.qty);
    }
}
```

This example uses the `M:System.Xml.Linq.XElement.Element` method that was introduced in the topic How to: Retrieve a Single Child Element (LINQ to XML) (C#). It also uses casts to retrieve the values of the elements that are returned by the `M:System.Xml.Linq.XElement.Element` method.

This example produces the following output:

```
Lawnmower:1
Baby Monitor:2
```

See also

- Projections and Transformations (LINQ to XML) (C#)

How to: Project an Object Graph (C#)

1/23/2019 • 3 minutes to read • Edit Online

This topic illustrates how to project, or populate, an object graph from XML.

Example

The following code populates an object graph with the `Address`, `PurchaseOrder`, and `PurchaseOrderItem` classes from the Sample XML File: Typical Purchase Order (LINQ to XML) XML document.

```
class Address
{
    public enum AddressUse
    {
        Shipping,
        Billing,
    }

    private AddressUse addressType;
    private string name;
    private string street;
    private string city;
    private string state;
    private string zip;
    private string country;

    public AddressUse AddressType {
        get { return addressType; } set { addressType = value; }
    }

    public string Name {
        get { return name; } set { name = value; }
    }

    public string Street {
        get { return street; } set { street = value; }
    }

    public string City {
        get { return city; } set { city = value; }
    }

    public string State {
        get { return state; } set { state = value; }
    }

    public string Zip {
        get { return zip; } set { zip = value; }
    }

    public string Country {
        get { return country; } set { country = value; }
    }

    public override string ToString()
    {
        StringBuilder sb = new StringBuilder();
        sb.Append($"Type: {(addressType == AddressUse.Shipping ? "Shipping" : "Billing")}\n");
        sb.Append($"Name: {name}\n");
        sb.Append($"Street: {street}\n");
        sb.Append($"City: {city}\n");
        sb.Append($"State: {state}\n");
        sb.Append($"Zip: {zip}\n");
        sb.Append($"Country: {country}\n");
        return sb.ToString();
    }
}

class PurchaseOrderItem
{
    private string partNumber;
    private string productName;
    private int quantity;
    private Decimal usPrice;
    private string comment;
    private DateTime shipDate;

    public string PartNumber {
        get { return partNumber; } set { partNumber = value; }
    }

    public string ProductName {
        get { return productName; } set { productName = value; }
    }

    public int Quantity {
        get { return quantity; } set { quantity = value; }
    }

    public Decimal USPrice {
        get { return usPrice; } set { usPrice = value; }
    }

    public string Comment {
        get { return comment; } set { comment = value; }
    }

    public DateTime ShipDate {
        get { return shipDate; } set { shipDate = value; }
    }

    public override string ToString()
    {
        StringBuilder sb = new StringBuilder();
        sb.Append($"PartNumber: {partNumber}\n");
        sb.Append($"ProductName: {productName}\n");
        sb.Append($"Quantity: {quantity}\n");
        sb.Append($"USPrice: {usPrice}\n");
        if (comment != null)
            sb.Append($"Comment: {comment}\n");
        if (shipDate != DateTime.MinValue)
            sb.Append($"ShipDate: {shipDate:d}\n");
        return sb.ToString();
    }
}

class PurchaseOrder
{
    private string purchaseOrderNumber;
    private DateTime orderDate;
    private string comment;
    private List<Address> addresses;
    private List<PurchaseOrderItem> items;

    public string PurchaseOrderNumber {
        get { return purchaseOrderNumber; } set { purchaseOrderNumber = value; }
    }

    public DateTime OrderDate {
        get { return orderDate; } set { orderDate = value; }
        get { return orderDate; } set { orderDate = value; }
    }

    public string Comment {
        get { return comment; } set { comment = value; }
    }

    public List<Address> Addresses {
        get { return addresses; } set { addresses = value; }
    }

    public List<PurchaseOrderItem> Items {
        get { return items; } set { items = value; }
    }

    public override string ToString()
    {
        StringBuilder sb = new StringBuilder();
        sb.Append($"PurchaseOrderNumber: {purchaseOrderNumber}\n");
        sb.Append($"OrderDate: {orderDate:d}\n");
        sb.Append("\n");
        sb.Append("Addresses\n");
        sb.Append("=====\n");
        foreach (Address address in addresses)
        {
            sb.Append(address);
            sb.Append("\n");
        }
        sb.Append("Items\n");
        sb.Append("=====\n");
        foreach (PurchaseOrderItem item in items)
        {
            sb.Append(item);
            sb.Append("\n");
        }
        return sb.ToString();
    }
}

class Program {
    public static void Main()
    {
        XElement po = XElement.Load("PurchaseOrder.xml");
        PurchaseOrder purchaseOrder = new PurchaseOrder {
            PurchaseOrderNumber = (string)po.Attribute("PurchaseOrderNumber"),
            OrderDate = (DateTime)po.Attribute("OrderDate"),
            Addresses = (
                            from a in po.Elements("Address")
                            select new Address {
                                AddressType = ((string)a.Attribute("Type") == "Shipping") ?
                                    Address.AddressUse.Shipping :
                                    Address.AddressUse.Billing,
                                Name = (string)a.Element("Name"),
                                Street = (string)a.Element("Street"),
                                City = (string)a.Element("City"),
                                State = (string)a.Element("State"),
                                Zip = (string)a.Element("Zip"),
                                Country = (string)a.Element("Country")
                            }
                        ).ToList(),
            Items = (
                        from i in po.Element("Items").Elements("Item")
                        select new PurchaseOrderItem {
                            PartNumber = (string)i.Attribute("PartNumber"),
                            ProductName = (string)i.Element("ProductName"),
                            Quantity = (int)i.Element("Quantity"),
                            USPrice = (Decimal)i.Element("USPrice"),
                            Comment = (string)i.Element("Comment"),
                            ShipDate = (i.Element("ShipDate") != null) ?
                                (DateTime)i.Element("ShipDate") :
```

```
                                (DateTime)i.Element("ShipDate") :
                                DateTime.MinValue
                        }
                    ).ToList()
        };
        Console.WriteLine(purchaseOrder);
    }
}
```

In this example, the result of the LINQ query is returned as an IEnumerable<T> of `PurchaseOrderItem`. The items in the `PurchaseOrder` class are of type IEnumerable<T> of `PurchaseOrderItem`. The code uses the ToList extension method to create a List<T> collection from the results of the query.

The example produces the following output:

```
PurchaseOrderNumber: 99503
OrderDate: 10/20/1999

Addresses
=====
Type: Shipping
Name: Ellen Adams
Street: 123 Maple Street
City: Mill Valley
State: CA
Zip: 10999
Country: USA

Type: Billing
Name: Tai Yee
Street: 8 Oak Avenue
City: Old Town
State: PA
Zip: 95819
Country: USA

Items
=====
PartNumber: 872-AA
ProductName: Lawnmower
Quantity: 1
USPrice: 148.95
Comment: Confirm this is electric

PartNumber: 926-AA
ProductName: Baby Monitor
Quantity: 2
USPrice: 39.98
ShipDate: 5/21/1999
```

See also

- Select
- ToList
- Projections and Transformations (LINQ to XML) (C#)

How to: Project an Anonymous Type (C#)

1/23/2019 • 2 minutes to read • Edit Online

In some cases you might want to project a query to a new type, even though you know you will only use this type for a short while. It is a lot of extra work to create a new type just to use in the projection. A more efficient approach in this case is to project to an anonymous type. Anonymous types allow you to define a class, then declare and initialize an object of that class, without giving the class a name.

Anonymous types are the C# implementation of the mathematical concept of a *tuple*. The mathematical term tuple originated from the sequence single, double, triple, quadruple, quintuple, n-tuple. It refers to a finite sequence of objects, each of a specific type. Sometimes this is called a list of name/value pairs. For example, the contents of an address in the Sample XML File: Typical Purchase Order (LINQ to XML) XML document could be expressed as follows:

```
Name: Ellen Adams
Street: 123 Maple Street
City: Mill Valley
State: CA
Zip: 90952
Country: USA
```

When you create an instance of an anonymous type, it is convenient to think of it as creating a tuple of order n. If you write a query that creates a tuple in the `select` clause, the query returns an `IEnumerable` of the tuple.

Example

In this example, the `select` clause projects an anonymous type. The example then uses `var` to create the `IEnumerable` object. Within the `foreach` loop, the iteration variable becomes an instance of the anonymous type created in the query expression.

This example uses the following XML document: Sample XML File: Customers and Orders (LINQ to XML).

```
XElement custOrd = XElement.Load("CustomersOrders.xml");
var custList =
    from el in custOrd.Element("Customers").Elements("Customer")
    select new {
        CustomerID = (string)el.Attribute("CustomerID"),
        CompanyName = (string)el.Element("CompanyName"),
        ContactName = (string)el.Element("ContactName")
    };
foreach (var cust in custList)
    Console.WriteLine("{0}:{1}:{2}", cust.CustomerID, cust.CompanyName, cust.ContactName);
```

This code produces the following output:

```
GREAL:Great Lakes Food Market:Howard Snyder
HUNGC:Hungry Coyote Import Store:Yoshi Latimer
LAZYK:Lazy K Kountry Store:John Steel
LETSS:Let's Stop N Shop:Jaime Yorres
```

See also

- Projections and Transformations (LINQ to XML) (C#)

How to: Generate Text Files from XML (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example shows how to generate a comma-separated values (CSV) file from an XML file.

Example

The C# version of this example uses method syntax and the `Aggregate` operator to generate a CSV file from an XML document in a single expression. For more information, see Query Syntax and Method Syntax in LINQ.

This example uses the following XML document: Sample XML File: Customers and Orders (LINQ to XML).

```
XElement custOrd = XElement.Load("CustomersOrders.xml");
string csv =
    (from el in custOrd.Element("Customers").Elements("Customer")
    select
        String.Format("{0},{1},{2},{3},{4},{5},{6},{7},{8},{9}{10}",
            (string)el.Attribute("CustomerID"),
            (string)el.Element("CompanyName"),
            (string)el.Element("ContactName"),
            (string)el.Element("ContactTitle"),
            (string)el.Element("Phone"),
            (string)el.Element("FullAddress").Element("Address"),
            (string)el.Element("FullAddress").Element("City"),
            (string)el.Element("FullAddress").Element("Region"),
            (string)el.Element("FullAddress").Element("PostalCode"),
            (string)el.Element("FullAddress").Element("Country"),
            Environment.NewLine
        )
    )
    .Aggregate(
        new StringBuilder(),
        (sb, s) => sb.Append(s),
        sb => sb.ToString()
    );
Console.WriteLine(csv);
```

This code produces the following output:

```
GREAL,Great Lakes Food Market,Howard Snyder,Marketing Manager,(503) 555-7555,2732 Baker
Blvd.,Eugene,OR,97403,USA
HUNGC,Hungry Coyote Import Store,Yoshi Latimer,Sales Representative,(503) 555-6874,City Center Plaza 516 Main
St.,Elgin,OR,97827,USA
LAZYK,Lazy K Kountry Store,John Steel,Marketing Manager,(509) 555-7969,12 Orchestra Terrace,Walla
Walla,WA,99362,USA
LETSS,Let's Stop N Shop,Jaime Yorres,Owner,(415) 555-5938,87 Polk St. Suite 5,San Francisco,CA,94117,USA
```

See also

- Projections and Transformations (LINQ to XML) (C#)

How to: Generate XML from CSV Files (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example shows how to use Language-Integrated Query (LINQ) and LINQ to XML to generate an XML file from a comma-separated value (CSV) file.

Example

The following code performs a LINQ query on an array of strings.

The query uses the `let` clause to split each string into an array of fields.

```
// Create the text file.
string csvString = @"GREAL,Great Lakes Food Market,Howard Snyder,Marketing Manager,(503) 555-7555,2732 Baker
Blvd.,Eugene,OR,97403,USA
HUNGC,Hungry Coyote Import Store,Yoshi Latimer,Sales Representative,(503) 555-6874,City Center Plaza 516 Main
St.,Elgin,OR,97827,USA
LAZYK,Lazy K Kountry Store,John Steel,Marketing Manager,(509) 555-7969,12 Orchestra Terrace,Walla
Walla,WA,99362,USA
LETSS,Let's Stop N Shop,Jaime Yorres,Owner,(415) 555-5938,87 Polk St. Suite 5,San Francisco,CA,94117,USA";
File.WriteAllText("cust.csv", csvString);

// Read into an array of strings.
string[] source = File.ReadAllLines("cust.csv");
XElement cust = new XElement("Root",
    from str in source
    let fields = str.Split(',')
    select new XElement("Customer",
        new XAttribute("CustomerID", fields[0]),
        new XElement("CompanyName", fields[1]),
        new XElement("ContactName", fields[2]),
        new XElement("ContactTitle", fields[3]),
        new XElement("Phone", fields[4]),
        new XElement("FullAddress",
            new XElement("Address", fields[5]),
            new XElement("City", fields[6]),
            new XElement("Region", fields[7]),
            new XElement("PostalCode", fields[8]),
            new XElement("Country", fields[9])
        )
    )
);
Console.WriteLine(cust);
```

This code produces the following output:

```xml
<Root>
  <Customer CustomerID="GREAL">
    <CompanyName>Great Lakes Food Market</CompanyName>
    <ContactName>Howard Snyder</ContactName>
    <ContactTitle>Marketing Manager</ContactTitle>
    <Phone>(503) 555-7555</Phone>
    <FullAddress>
      <Address>2732 Baker Blvd.</Address>
      <City>Eugene</City>
      <Region>OR</Region>
      <PostalCode>97403</PostalCode>
      <Country>USA</Country>
    </FullAddress>
  </Customer>
  <Customer CustomerID="HUNGC">
    <CompanyName>Hungry Coyote Import Store</CompanyName>
    <ContactName>Yoshi Latimer</ContactName>
    <ContactTitle>Sales Representative</ContactTitle>
    <Phone>(503) 555-6874</Phone>
    <FullAddress>
      <Address>City Center Plaza 516 Main St.</Address>
      <City>Elgin</City>
      <Region>OR</Region>
      <PostalCode>97827</PostalCode>
      <Country>USA</Country>
    </FullAddress>
  </Customer>
  <Customer CustomerID="LAZYK">
    <CompanyName>Lazy K Kountry Store</CompanyName>
    <ContactName>John Steel</ContactName>
    <ContactTitle>Marketing Manager</ContactTitle>
    <Phone>(509) 555-7969</Phone>
    <FullAddress>
      <Address>12 Orchestra Terrace</Address>
      <City>Walla Walla</City>
      <Region>WA</Region>
      <PostalCode>99362</PostalCode>
      <Country>USA</Country>
    </FullAddress>
  </Customer>
  <Customer CustomerID="LETSS">
    <CompanyName>Let's Stop N Shop</CompanyName>
    <ContactName>Jaime Yorres</ContactName>
    <ContactTitle>Owner</ContactTitle>
    <Phone>(415) 555-5938</Phone>
    <FullAddress>
      <Address>87 Polk St. Suite 5</Address>
      <City>San Francisco</City>
      <Region>CA</Region>
      <PostalCode>94117</PostalCode>
      <Country>USA</Country>
    </FullAddress>
  </Customer>
</Root>
```

See also

- Projections and Transformations (LINQ to XML) (C#)

Advanced Query Techniques (LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This section provides examples of more advanced LINQ to XML query techniques.

In This Section

TOPIC	DESCRIPTION
How to: Join Two Collections (LINQ to XML) (C#)	Shows how to use the `Join` clause to take advantage of relationships in XML data.
How to: Create Hierarchy Using Grouping (C#)	Shows how to group data, and then generate XML based on the grouping.
How to: Query LINQ to XML Using XPath (C#)	Shows how to retrieve collections based on XPath queries.
How to: Write a LINQ to XML Axis Method (C#)	Shows how to write a LINQ to XML axis method.
How to: Perform Streaming Transformations of Text to XML (C#)	Shows how to transform very large text files into XML while maintaining a small memory footprint.
How to: List All Nodes in a Tree (C#)	Presents a utility method that lists all nodes in an XML tree. This is useful for debugging code that modifies an XML tree.
How to: Retrieve Paragraphs from an Office Open XML Document (C#)	Presents code that opens an Office Open XML Document, retrieves the paragraphs in a collection of XElement objects, the text of the paragraphs, and the style of the paragraphs.
How to: Modify an Office Open XML Document (C#)	Presents code that opens, modifies, and saves an Office Open XML Document.
How to: Populate an XML Tree from the File System (C#)	Presents code that creates an XML tree from the file system.

See also

- Querying XML Trees (C#)

How to: Join Two Collections (LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

An element or attribute in an XML document can sometimes refer to another element or attribute. For example, the Sample XML File: Customers and Orders (LINQ to XML) XML document contains a list of customers and a list of orders. Each `Customer` element contains a `CustomerID` attribute. Each `Order` element contains a `CustomerID` element. The `CustomerID` element in each order refers to the `CustomerID` attribute in a customer.

The topic Sample XSD File: Customers and Orders contains an XSD that can be used to validate this document. It uses the `xs:key` and `xs:keyref` features of XSD to establish that the `CustomerID` attribute of the `Customer` element is a key, and to establish a relationship between the `CustomerID` element in each `Order` element and the `CustomerID` attribute in each `Customer` element.

With LINQ to XML, you can take advantage of this relationship by using the `join` clause.

Note that because there is no index available, such joining will have poor runtime performance.

For more detailed information about `join`, see Join Operations (C#).

Example

The following example joins the `Customer` elements to the `Order` elements, and generates a new XML document that includes the `CompanyName` element in the orders.

Before executing the query, the example validates that the document complies with the schema in Sample XSD File: Customers and Orders. This ensures that the join clause will always work.

This query first retrieves all `Customer` elements, and then joins them to the `Order` elements. It selects only the orders for customers with a `CustomerID` greater than "K". It then projects a new `Order` element that contains the customer information within each order.

This example uses the following XML document: Sample XML File: Customers and Orders (LINQ to XML).

This example uses the following XSD schema: Sample XSD File: Customers and Orders.

Note that joining in this fashion will not perform very well. Joins are performed via a linear search. There are no hash tables or indexes to help with performance.

```
XmlSchemaSet schemas = new XmlSchemaSet();
schemas.Add("", "CustomersOrders.xsd");

Console.Write("Attempting to validate, ");
XDocument custOrdDoc = XDocument.Load("CustomersOrders.xml");

bool errors = false;
custOrdDoc.Validate(schemas, (o, e) =>
                     {
                         Console.WriteLine("{0}", e.Message);
                         errors = true;
                     });
Console.WriteLine("custOrdDoc {0}", errors ? "did not validate" : "validated");

if (!errors)
{
    // Join customers and orders, and create a new XML document with
    // a different shape.

    // The new document contains orders only for customers with a
    // CustomerID > 'K'
    XElement custOrd = custOrdDoc.Element("Root");
    XElement newCustOrd = new XElement("Root",
        from c in custOrd.Element("Customers").Elements("Customer")
        join o in custOrd.Element("Orders").Elements("Order")
                   on (string)c.Attribute("CustomerID") equals
                      (string)o.Element("CustomerID")
        where ((string)c.Attribute("CustomerID")).CompareTo("K") > 0
        select new XElement("Order",
            new XElement("CustomerID", (string)c.Attribute("CustomerID")),
            new XElement("CompanyName", (string)c.Element("CompanyName")),
            new XElement("ContactName", (string)c.Element("ContactName")),
            new XElement("EmployeeID", (string)o.Element("EmployeeID")),
            new XElement("OrderDate", (DateTime)o.Element("OrderDate"))
        )
    );
    Console.WriteLine(newCustOrd);
}
```

This code produces the following output:

```
Attempting to validate, custOrdDoc validated
<Root>
  <Order>
    <CustomerID>LAZYK</CustomerID>
    <CompanyName>Lazy K Kountry Store</CompanyName>
    <ContactName>John Steel</ContactName>
    <EmployeeID>1</EmployeeID>
    <OrderDate>1997-03-21T00:00:00</OrderDate>
  </Order>
  <Order>
    <CustomerID>LAZYK</CustomerID>
    <CompanyName>Lazy K Kountry Store</CompanyName>
    <ContactName>John Steel</ContactName>
    <EmployeeID>8</EmployeeID>
    <OrderDate>1997-05-22T00:00:00</OrderDate>
  </Order>
  <Order>
    <CustomerID>LETSS</CustomerID>
    <CompanyName>Let's Stop N Shop</CompanyName>
    <ContactName>Jaime Yorres</ContactName>
    <EmployeeID>1</EmployeeID>
    <OrderDate>1997-06-25T00:00:00</OrderDate>
  </Order>
  <Order>
    <CustomerID>LETSS</CustomerID>
    <CompanyName>Let's Stop N Shop</CompanyName>
    <ContactName>Jaime Yorres</ContactName>
    <EmployeeID>8</EmployeeID>
    <OrderDate>1997-10-27T00:00:00</OrderDate>
  </Order>
  <Order>
    <CustomerID>LETSS</CustomerID>
    <CompanyName>Let's Stop N Shop</CompanyName>
    <ContactName>Jaime Yorres</ContactName>
    <EmployeeID>6</EmployeeID>
    <OrderDate>1997-11-10T00:00:00</OrderDate>
  </Order>
  <Order>
    <CustomerID>LETSS</CustomerID>
    <CompanyName>Let's Stop N Shop</CompanyName>
    <ContactName>Jaime Yorres</ContactName>
    <EmployeeID>4</EmployeeID>
    <OrderDate>1998-02-12T00:00:00</OrderDate>
  </Order>
</Root>
```

See also

- Advanced Query Techniques (LINQ to XML) (C#)

How to: Create Hierarchy Using Grouping (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example shows how to group data, and then generate XML based on the grouping.

Example

This example first groups data by a category, then generates a new XML file in which the XML hierarchy reflects the grouping.

This example uses the following XML document: Sample XML File: Numerical Data (LINQ to XML).

```
XElement doc = XElement.Load("Data.xml");
var newData =
    new XElement("Root",
        from data in doc.Elements("Data")
        group data by (string)data.Element("Category") into groupedData
        select new XElement("Group",
            new XAttribute("ID", groupedData.Key),
            from g in groupedData
            select new XElement("Data",
                g.Element("Quantity"),
                g.Element("Price")
            )
        )
    );
Console.WriteLine(newData);
```

This example produces the following output:

```xml
<Root>
  <Group ID="A">
    <Data>
      <Quantity>3</Quantity>
      <Price>24.50</Price>
    </Data>
    <Data>
      <Quantity>5</Quantity>
      <Price>4.95</Price>
    </Data>
    <Data>
      <Quantity>3</Quantity>
      <Price>66.00</Price>
    </Data>
    <Data>
      <Quantity>15</Quantity>
      <Price>29.00</Price>
    </Data>
  </Group>
  <Group ID="B">
    <Data>
      <Quantity>1</Quantity>
      <Price>89.99</Price>
    </Data>
    <Data>
      <Quantity>10</Quantity>
      <Price>.99</Price>
    </Data>
    <Data>
      <Quantity>8</Quantity>
      <Price>6.99</Price>
    </Data>
  </Group>
</Root>
```

See also

- Advanced Query Techniques (LINQ to XML) (C#)

How to: Query LINQ to XML Using XPath (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic introduces the extension methods that enable you to query an XML tree by using XPath. For detailed information about using these extension methods, see System.Xml.XPath.Extensions.

Unless you have a very specific reason for querying using XPath, such as extensive use of legacy code, using XPath with LINQ to XML is not recommended. XPath queries will not perform as well as LINQ to XML queries.

Example

The following example creates a small XML tree and uses XPathSelectElements to select a set of elements.

```
XElement root = new XElement("Root",
    new XElement("Child1", 1),
    new XElement("Child1", 2),
    new XElement("Child1", 3),
    new XElement("Child2", 4),
    new XElement("Child2", 5),
    new XElement("Child2", 6)
);
IEnumerable<XElement> list = root.XPathSelectElements("./Child2");
foreach (XElement el in list)
    Console.WriteLine(el);
```

This example produces the following output:

```
<Child2>4</Child2>
<Child2>5</Child2>
<Child2>6</Child2>
```

See also

- Advanced Query Techniques (LINQ to XML) (C#)

How to: Write a LINQ to XML Axis Method (C#)

1/23/2019 • 3 minutes to read • Edit Online

You can write your own axis methods to retrieve collections from an XML tree. One of the best ways to do this is to write an extension method that returns a collection of elements or attributes. You can write your extension method to return specific subsets of elements or attributes, based on the requirements of your application.

Example

The following example uses two extension methods. The first extension method, `GetXPath`, operates on XObject, and returns an XPath expression that when evaluated will return the node or attribute. The second extension method, `Find`, operates on XElement. It returns a collection of XAttribute objects and XElement objects that contain some specified text.

This example uses the following XML document: Sample XML File: Multiple Purchase Orders (LINQ to XML).

```
public static class MyExtensions
{
    private static string GetQName(XElement xe)
    {
        string prefix = xe.GetPrefixOfNamespace(xe.Name.Namespace);
        if (xe.Name.Namespace == XNamespace.None || prefix == null)
            return xe.Name.LocalName.ToString();
        else
            return prefix + ":" + xe.Name.LocalName.ToString();
    }

    private static string GetQName(XAttribute xa)
    {
        string prefix =
            xa.Parent.GetPrefixOfNamespace(xa.Name.Namespace);
        if (xa.Name.Namespace == XNamespace.None || prefix == null)
            return xa.Name.ToString();
        else
            return prefix + ":" + xa.Name.LocalName;
    }

    private static string NameWithPredicate(XElement el)
    {
        if (el.Parent != null && el.Parent.Elements(el.Name).Count() != 1)
            return GetQName(el) + "[" +
                (el.ElementsBeforeSelf(el.Name).Count() + 1) + "]";
        else
            return GetQName(el);
    }

    public static string StrCat<T>(this IEnumerable<T> source,
        string separator)
    {
        return source.Aggregate(new StringBuilder(),
                   (sb, i) => sb
                       .Append(i.ToString())
                       .Append(separator),
                   s => s.ToString());
    }

    public static string GetXPath(this XObject xobj)
    {
        if (xobj.Parent == null)
        {
            XDocument doc = xobj as XDocument;
            if (doc != null)
                return ".";
            XElement el = xobj as XElement;
            if (el != null)
                return "/" + NameWithPredicate(el);
            // the XPath data model does not include white space text nodes
            // that are children of a document, so this method returns null.
            XText xt = xobj as XText;
            if (xt != null)
                return null;
            XComment com = xobj as XComment;
            if (com != null)
                return
                    "/" +
                    (
                        com
                        .Document
                        .Nodes()
                        .OfType<XComment>()
                        .Count() != 1 ?
                        "comment()[" +
                        (com
                        .NodesBeforeSelf()
                        .OfType<XComment>()
                        .Count() + 1) +
                        "]" :
                        "comment()"
                    );
            XProcessingInstruction pi = xobj as XProcessingInstruction;
            if (pi != null)
                return
                    "/" +
                    (
                        pi.Document.Nodes()
                        .OfType<XProcessingInstruction>()
                        .Count() != 1 ?
                        "processing-instruction()[" +
                        (pi
                        .NodesBeforeSelf()
                        .OfType<XProcessingInstruction>()
                        .Count() + 1) +
                        "]" :
                        "processing-instruction()"
                    );
            return null;
        }
        else
        {
            XElement el = xobj as XElement;
            if (el != null)
            {
                return
                    "/" +
                    el
                    .Ancestors()
                    .InDocumentOrder()
                    .Select(e => NameWithPredicate(e))
                    .StrCat("/") +
                    NameWithPredicate(el);
            }
            XAttribute at = xobj as XAttribute;
            if (at != null)
                return
                    "/" +
                    at
                    .Parent
                    .AncestorsAndSelf()
                    .InDocumentOrder()
                    .Select(e => NameWithPredicate(e))
                    .StrCat("/") +
                    "@" + GetQName(at);
            XComment com = xobj as XComment;
            if (com != null)
                return
                    "/" +
                    com
                    .Parent
                    .AncestorsAndSelf()
                    .InDocumentOrder()
                    .Select(e => NameWithPredicate(e))
                    .StrCat("/") +
                    (
                        com
                        .Parent
                        .Nodes()
                        .OfType<XComment>()
                        .Count() != 1 ?
                        "comment()[" +
                        (com
                        .NodesBeforeSelf()
                        .OfType<XComment>()
                        .Count() + 1) + "]" :
                        "comment()"
                    );
            XCData cd = xobj as XCData;
            if (cd != null)
                return
                    "/" +
                    cd
                    .Parent
                    .AncestorsAndSelf()
                    .InDocumentOrder()
                    .Select(e => NameWithPredicate(e))
                    .StrCat("/") +
                    (
                        cd
                        .Parent
                        .Nodes()
                        .OfType<XText>()
                        .Count() != 1 ?
                        "text()[" +
                        (cd
                        .NodesBeforeSelf()
                        .OfType<XText>()
                        .Count() + 1) + "]" :
                        "text()"
                    );
            XText tx = xobj as XText;
            if (tx != null)
                return
                    "/" +
                    tx
                    .Parent
                    .AncestorsAndSelf()
                    .InDocumentOrder()
                    .Select(e => NameWithPredicate(e))
                    .StrCat("/") +
                    (
                        tx
                        .Parent
                        .Nodes()
                        .OfType<XText>()
                        .Count() != 1 ?
                        "text()[" +
                        (tx
                        .NodesBeforeSelf()
```

```
                        .OfType<XText>()
                        .Count() + 1) + "]" :
                        "text()"
                    );
            XProcessingInstruction pi = xobj as XProcessingInstruction;
            if (pi != null)
                return
                    "/" +
                    pi
                    .Parent
                    .AncestorsAndSelf()
                    .InDocumentOrder()
                    .Select(e => NameWithPredicate(e))
                    .StrCat("/") +
                    (
                        pi
                        .Parent
                        .Nodes()
                        .OfType<XProcessingInstruction>()
                        .Count() != 1 ?
                        "processing-instruction()[" +
                        (pi
                        .NodesBeforeSelf()
                        .OfType<XProcessingInstruction>()
                        .Count() + 1) + "]" :
                        "processing-instruction()"
                    );
            return null;
        }
    }

    public static IEnumerable<XObject> Find(this XElement source, string value)
    {
        if (source.Attributes().Any())
        {
            foreach (XAttribute att in source.Attributes())
            {
                string contents = (string)att;
                if (contents.Contains(value))
                    yield return att;
            }
        }
        if (source.Elements().Any())
        {
            foreach (XElement child in source.Elements())
                foreach (XObject s in child.Find(value))
                    yield return s;
        }
        else
        {
            string contents = (string)source;
            if (contents.Contains(value))
                yield return source;
        }
    }
}

class Program
{
    static void Main(string[] args)
    {
        XElement purchaseOrders = XElement.Load("PurchaseOrders.xml");

        IEnumerable<XObject> subset =
            from xobj in purchaseOrders.Find("1999")
            select xobj;

        foreach (XObject obj in subset)
        {
            Console.WriteLine(obj.GetXPath());
            if (obj.GetType() == typeof(XElement))
                Console.WriteLine(((XElement)obj).Value);
            else if (obj.GetType() == typeof(XAttribute))
                Console.WriteLine(((XAttribute)obj).Value);
        }
    }
}
```

This code produces the following output:

```
/PurchaseOrders/PurchaseOrder[1]/@OrderDate
1999-10-20
/PurchaseOrders/PurchaseOrder[1]/Items/Item[2]/ShipDate
1999-05-21
/PurchaseOrders/PurchaseOrder[2]/@OrderDate
1999-10-22
/PurchaseOrders/PurchaseOrder[3]/@OrderDate
1999-10-22
```

See also

- Advanced Query Techniques (LINQ to XML) (C#)

How to: Perform Streaming Transformations of Text to XML (C#)

1/23/2019 • 2 minutes to read • Edit Online

One approach to processing a text file is to write an extension method that streams the text file a line at a time using the `yield return` construct. You then can write a LINQ query that processes the text file in a lazy deferred fashion. If you then use XStreamingElement to stream output, you then can create a transformation from the text file to XML that uses a minimal amount of memory, regardless of the size of the source text file.

There are some caveats regarding streaming transformations. A streaming transformation is best applied in situations where you can process the entire file once, and if you can process the lines in the order that they occur in the source document. If you have to process the file more than once, or if you have to sort the lines before you can process them, you will lose many of the benefits of using a streaming technique.

Example

The following text file, People.txt, is the source for this example.

```
#This is a comment
1,Tai,Yee,Writer
2,Nikolay,Grachev,Programmer
3,David,Wright,Inventor
```

The following code contains an extension method that streams the lines of the text file in a deferred fashion.

```
public static class StreamReaderSequence
{
    public static IEnumerable<string> Lines(this StreamReader source)
    {
        String line;

        if (source == null)
            throw new ArgumentNullException("source");
        while ((line = source.ReadLine()) != null)
        {
            yield return line;
        }
    }
}

class Program
{
    static void Main(string[] args)
    {
        StreamReader sr = new StreamReader("People.txt");
        XStreamingElement xmlTree = new XStreamingElement("Root",
            from line in sr.Lines()
            let items = line.Split(',')
            where !line.StartsWith("#")
            select new XElement("Person",
                       new XAttribute("ID", items[0]),
                       new XElement("First", items[1]),
                       new XElement("Last", items[2]),
                       new XElement("Occupation", items[3])
                   )
        );
        Console.WriteLine(xmlTree);
        sr.Close();
    }
}
```

This example produces the following output:

```
<Root>
  <Person ID="1">
    <First>Tai</First>
    <Last>Yee</Last>
    <Occupation>Writer</Occupation>
  </Person>
  <Person ID="2">
    <First>Nikolay</First>
    <Last>Grachev</Last>
    <Occupation>Programmer</Occupation>
  </Person>
  <Person ID="3">
    <First>David</First>
    <Last>Wright</Last>
    <Occupation>Inventor</Occupation>
  </Person>
</Root>
```

See also

- XStreamingElement
- Advanced Query Techniques (LINQ to XML) (C#)

How to: List All Nodes in a Tree (C#)

1/23/2019 • 4 minutes to read • Edit Online

Sometimes it is helpful to list all nodes in a tree. This can be useful when learning exactly how a method or property affects the tree. One approach to listing all nodes in a textual form is to generate an XPath expression that exactly and specifically identifies any node in the tree.

It is not particularly helpful to execute XPath expressions using LINQ to XML. XPath expressions have poorer performance than LINQ to XML queries, and LINQ to XML queries are much more powerful. However, as a way to identify nodes in the XML tree, XPath works well.

Example

This example shows an function named `GetXPath` that generates a specific XPath expression for any node in the XML tree. It generates appropriate XPath expressions even when nodes are in a namespace. The XPath expressions are generated by using namespace prefixes.

The example then creates a small XML tree that contains an example of several types of nodes. It then iterates through the descendant nodes and prints the XPath expression for each node.

You will notice that the XML declaration is not a node in the tree.

The following is an XML file that contains several types of nodes:

```
<?xml version="1.0" encoding="utf-8" standalone="yes"?>
<?target data?>
<Root AttName="An Attribute" xmlns:aw="http://www.adventure-works.com">
  <!--This is a comment-->
  <Child>Text</Child>
  <Child>Other Text</Child>
  <ChildWithMixedContent>text<b>BoldText</b>otherText</ChildWithMixedContent>
  <aw:ElementInNamespace>
    <aw:ChildInNamespace />
  </aw:ElementInNamespace>
</Root>
```

The following is the list of nodes in the above XML tree, expressed as XPath expressions:

```
/processing-instruction()
/Root
/Root/@AttName
/Root/@xmlns:aw
/Root/comment()
/Root/Child[1]
/Root/Child[1]/text()
/Root/Child[2]
/Root/Child[2]/text()
/Root/ChildWithMixedContent
/Root/ChildWithMixedContent/text()[1]
/Root/ChildWithMixedContent/b
/Root/ChildWithMixedContent/b/text()
/Root/ChildWithMixedContent/text()[2]
/Root/aw:ElementInNamespace
/Root/aw:ElementInNamespace/aw:ChildInNamespace
```

```
public static class MyExtensions
{
    private static string GetQName(XElement xe)
    {
        string prefix = xe.GetPrefixOfNamespace(xe.Name.Namespace);
        if (xe.Name.Namespace == XNamespace.None || prefix == null)
            return xe.Name.LocalName.ToString();
        else
            return prefix + ":" + xe.Name.LocalName.ToString();
    }

    private static string GetQName(XAttribute xa)
    {
        string prefix =
            xa.Parent.GetPrefixOfNamespace(xa.Name.Namespace);
        if (xa.Name.Namespace == XNamespace.None || prefix == null)
            return xa.Name.ToString();
        else
            return prefix + ":" + xa.Name.LocalName;
    }

    private static string NameWithPredicate(XElement el)
    {
        if (el.Parent != null && el.Parent.Elements(el.Name).Count() != 1)
            return GetQName(el) + "[" +
                (el.ElementsBeforeSelf(el.Name).Count() + 1) + "]";
        else
            return GetQName(el);
    }

    public static string StrCat<T>(this IEnumerable<T> source,
        string separator)
    {
        return source.Aggregate(new StringBuilder(),
                   (sb, i) => sb
                       .Append(i.ToString())
                       .Append(separator),
                   s => s.ToString());
    }

    public static string GetXPath(this XObject xobj)
    {
        if (xobj.Parent == null)
        {
            XDocument doc = xobj as XDocument;
            if (doc != null)
                return ".";
            XElement el = xobj as XElement;
            if (el != null)
                return "/" + NameWithPredicate(el);
            // the XPath data model does not include white space text nodes
            // that are children of a document, so this method returns null.
            XText xt = xobj as XText;
            if (xt != null)
                return null;
            XComment com = xobj as XComment;
            if (com != null)
                return
                    "/" +
                    (
                        com
                        .Document
                        .Nodes()
                        .OfType<XComment>()
                        .Count() != 1 ?
                        "comment()[" +
                        (com
                        .NodesBeforeSelf()
                        .OfType<XComment>()
                        .Count() + 1) +
                        "]" :
                        "comment()"
                    );
            XProcessingInstruction pi = xobj as XProcessingInstruction;
            if (pi != null)
                return
                    "/" +
                    (
                        pi.Document.Nodes()
                        .OfType<XProcessingInstruction>()
                        .Count() != 1 ?
                        "processing-instruction()[" +
                        (pi
                        .NodesBeforeSelf()
                        .OfType<XProcessingInstruction>()
                        .Count() + 1) +
                        "]" :
                        "processing-instruction()"
                    );
            return null;
        }
        else
        {
            XElement el = xobj as XElement;
            if (el != null)
            {
                return
                    "/" +
                    el
                    .Ancestors()
                    .InDocumentOrder()
                    .Select(e => NameWithPredicate(e))
                    .StrCat("/") +
                    NameWithPredicate(el);
            }
            XAttribute at = xobj as XAttribute;
            if (at != null)
                return
                    "/" +
                    at
                    .Parent
                    .AncestorsAndSelf()
                    .InDocumentOrder()
                    .Select(e => NameWithPredicate(e))
                    .StrCat("/") +
                    "@" + GetQName(at);
            XComment com = xobj as XComment;
            if (com != null)
                return
                    "/" +
                    com
                    .Parent
                    .AncestorsAndSelf()
                    .InDocumentOrder()
                    .Select(e => NameWithPredicate(e))
                    .StrCat("/") +
                    (
                        com
                        .Parent
                        .Nodes()
                        .OfType<XComment>()
                        .Count() != 1 ?
                        "comment()[" +
                        (com
                        .NodesBeforeSelf()
                        .OfType<XComment>()
                        .Count() + 1) + "]" :
                        "comment()"
                    );
            XCData cd = xobj as XCData;
            if (cd != null)
                return
                    "/" +
                    cd
                    .Parent
                    .AncestorsAndSelf()
                    .InDocumentOrder()
                    .Select(e => NameWithPredicate(e))
                    .StrCat("/") +
                    (
                        cd
                        .Parent
                        .Nodes()
                        .OfType<XText>()
                        .Count() != 1 ?
                        "text()[" +
                        (cd
                        .NodesBeforeSelf()
                        .OfType<XText>()
                        .Count() + 1) + "]" :
                        "text()"
                    );
            XText tx = xobj as XText;
            if (tx != null)
                return
                    "/" +
                    tx
                    .Parent
                    .AncestorsAndSelf()
                    .InDocumentOrder()
                    .Select(e => NameWithPredicate(e))
                    .StrCat("/") +
                    (
                        tx
                        .Parent
                        .Nodes()
                        .OfType<XText>()
                        .Count() != 1 ?
                        "text()[" +
                        (tx
                        .NodesBeforeSelf()
                        .OfType<XText>()
                        .Count() + 1) + "]" :
                        "text()"
                    );
            XProcessingInstruction pi = xobj as XProcessingInstruction;
            if (pi != null)
                return
                    "/" +
                    pi
                    .Parent
                    .AncestorsAndSelf()
                    .InDocumentOrder()
                    .Select(e => NameWithPredicate(e))
                    .StrCat("/") +
                    (
                        pi
                        .Parent
                        .Nodes()
                        .OfType<XProcessingInstruction>()
                        .Count() != 1 ?
                        "processing-instruction()[" +
                        (pi
                        .NodesBeforeSelf()
                        .OfType<XProcessingInstruction>()
                        .Count() + 1) + "]" :
                        "processing-instruction()"
                    );
            return null;
        }
    }
}

class Program
{
    static void Main(string[] args)
    {
        XNamespace aw = "http://www.adventure-works.com";
        XDocument doc = new XDocument(
            new XDeclaration("1.0", "utf-8", "yes"),
            new XProcessingInstruction("target", "data"),
            new XElement("Root",
                new XAttribute("AttName", "An Attribute"),
                new XAttribute(XNamespace.Xmlns + "aw", aw.ToString()),
                new XComment("This is a comment"),
                new XElement("Child",
                    new XText("Text")
                ),
                new XElement("Child",
                    new XText("Other Text")
                ),
                new XElement("ChildWithMixedContent",
                    new XText("text"),
                    new XElement("b", "BoldText"),
                    new XText("otherText")
                ),
                new XElement(aw + "ElementInNamespace",
                    new XElement(aw + "ChildInNamespace")
                )
            )
        );
        doc.Save("Test.xml");
        Console.WriteLine(File.ReadAllText("Test.xml"));
        Console.WriteLine("------");
        foreach (XObject obj in doc.DescendantNodes())
        {
            Console.WriteLine(obj.GetXPath());
            XElement el = obj as XElement;
            if (el != null)
                foreach (XAttribute at in el.Attributes())
                    Console.WriteLine(at.GetXPath());
        }
    }
}
```

This example produces the following output:

```
<?xml version="1.0" encoding="utf-8" standalone="yes"?>
<?target data?>
<Root AttName="An Attribute" xmlns:aw="http://www.adventure-works.com">
  <!--This is a comment-->
  <Child>Text</Child>
  <Child>Other Text</Child>
  <ChildWithMixedContent>text<b>BoldText</b>otherText</ChildWithMixedContent>
  <aw:ElementInNamespace>
    <aw:ChildInNamespace />
  </aw:ElementInNamespace>
</Root>
------
/processing-instruction()
/Root
/Root/@AttName
/Root/@xmlns:aw
/Root/comment()
/Root/Child[1]
/Root/Child[1]/text()
/Root/Child[2]
/Root/Child[2]/text()
/Root/ChildWithMixedContent
/Root/ChildWithMixedContent/text()[1]
/Root/ChildWithMixedContent/b
/Root/ChildWithMixedContent/b/text()
/Root/ChildWithMixedContent/text()[2]
/Root/aw:ElementInNamespace
/Root/aw:ElementInNamespace/aw:ChildInNamespace
```

See also

- Advanced Query Techniques (LINQ to XML) (C#)

How to: Retrieve Paragraphs from an Office Open XML Document (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic presents an example that opens an Office Open XML document, and retrieves a collection of all of the paragraphs in the document.

For more information on Office Open XML, see Open XML SDK and www.ericwhite.com.

Example

This example opens an Office Open XML package, uses the relationships within the Open XML package to find the document and the style parts. It then queries the document, projecting a collection of an anonymous type that contains the paragraph XElement node, the style name of each paragraph, and the text of each paragraph.

The example uses an extension method named `StringConcatenate`, which is also supplied in the example.

For a detailed tutorial that explains how this example works, see Pure Functional Transformations of XML (C#).

This example uses classes found in the WindowsBase assembly. It uses types in the System.IO.Packaging namespace.

```
public static class LocalExtensions
{
    public static string StringConcatenate(this IEnumerable<string> source)
    {
        StringBuilder sb = new StringBuilder();
        foreach (string s in source)
            sb.Append(s);
        return sb.ToString();
    }

    public static string StringConcatenate<T>(this IEnumerable<T> source,
        Func<T, string> func)
    {
        StringBuilder sb = new StringBuilder();
        foreach (T item in source)
            sb.Append(func(item));
        return sb.ToString();
    }

    public static string StringConcatenate(this IEnumerable<string> source, string separator)
    {
        StringBuilder sb = new StringBuilder();
        foreach (string s in source)
            sb.Append(s).Append(separator);
        return sb.ToString();
    }

    public static string StringConcatenate<T>(this IEnumerable<T> source,
        Func<T, string> func, string separator)
    {
        StringBuilder sb = new StringBuilder();
        foreach (T item in source)
            sb.Append(func(item)).Append(separator);
        return sb.ToString();
    }
}
```

```
class Program
{
    public static string ParagraphText(XElement e)
    {
        XNamespace w = e.Name.Namespace;
        return e
               .Elements(w + "r")
               .Elements(w + "t")
               .StringConcatenate(element => (string)element);
    }

    static void Main(string[] args)
    {
        const string fileName = "SampleDoc.docx";

        const string documentRelationshipType =
          "http://schemas.openxmlformats.org/officeDocument/2006/relationships/officeDocument";
        const string stylesRelationshipType =
          "http://schemas.openxmlformats.org/officeDocument/2006/relationships/styles";
        const string wordmlNamespace =
          "http://schemas.openxmlformats.org/wordprocessingml/2006/main";
        XNamespace w = wordmlNamespace;

        XDocument xDoc = null;
        XDocument styleDoc = null;

        using (Package wdPackage = Package.Open(fileName, FileMode.Open, FileAccess.Read))
        {
            PackageRelationship docPackageRelationship =
              wdPackage
              .GetRelationshipsByType(documentRelationshipType)
              .FirstOrDefault();
            if (docPackageRelationship != null)
            {
                Uri documentUri =
                    PackUriHelper
                    .ResolvePartUri(
                       new Uri("/", UriKind.Relative),
                             docPackageRelationship.TargetUri);
                PackagePart documentPart =
                    wdPackage.GetPart(documentUri);

                //  Load the document XML in the part into an XDocument instance.
                xDoc = XDocument.Load(XmlReader.Create(documentPart.GetStream()));

                //  Find the styles part. There will only be one.
                PackageRelationship styleRelation =
                  documentPart.GetRelationshipsByType(stylesRelationshipType)
                  .FirstOrDefault();
                if (styleRelation != null)
                {
                    Uri styleUri = PackUriHelper.ResolvePartUri(documentUri, styleRelation.TargetUri);
                    PackagePart stylePart = wdPackage.GetPart(styleUri);

                    //  Load the style XML in the part into an XDocument instance.
                    styleDoc = XDocument.Load(XmlReader.Create(stylePart.GetStream()));
                }
            }
        }

        string defaultStyle =
            (string)(
                from style in styleDoc.Root.Elements(w + "style")
                where (string)style.Attribute(w + "type") == "paragraph" &&
                      (string)style.Attribute(w + "default") == "1"
                select style
            ).First().Attribute(w + "styleId");
        // Find all paragraphs in the document.
        var paragraphs =
            from para in xDoc
                         .Root
                         .Element(w + "body")
                         .Descendants(w + "p")
            let styleNode = para
                            .Elements(w + "pPr")
                            .Elements(w + "pStyle")
                            .FirstOrDefault()
            select new
            {
                ParagraphNode = para,
                StyleName = styleNode != null ?
                    (string)styleNode.Attribute(w + "val") :
                    defaultStyle
            };

        // Retrieve the text of each paragraph.
        var paraWithText =
            from para in paragraphs
            select new
            {
                ParagraphNode = para.ParagraphNode,
                StyleName = para.StyleName,
                Text = ParagraphText(para.ParagraphNode)
            };

        foreach (var p in paraWithText)
            Console.WriteLine("StyleName:{0} >{1}<", p.StyleName, p.Text);
    }
}
```

When run with the sample Open XML document described in Creating the Source Office Open XML Document (C#), this example produces the following output:

```
StyleName:Heading1 >Parsing WordprocessingML with LINQ to XML<
StyleName:Normal ><
StyleName:Normal >The following example prints to the console.<
StyleName:Normal ><
StyleName:Code >using System;<
StyleName:Code ><
StyleName:Code >class Program {<
StyleName:Code >    public static void (string[] args) {<
StyleName:Code >        Console.WriteLine("Hello World");<
StyleName:Code >    }<
StyleName:Code >}<
StyleName:Normal ><
StyleName:Normal >This example produces the following output:<
StyleName:Normal ><
StyleName:Code >Hello World<
```

See also

- Advanced Query Techniques (LINQ to XML) (C#)

How to: Modify an Office Open XML Document (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic presents an example that opens an Office Open XML document, modifies it, and saves it.

For more information on Office Open XML, see Open XML SDK and www.ericwhite.com.

Example

This example finds the first paragraph element in the document. It retrieves the text from the paragraph, and then deletes all text runs in the paragraph. It creates a new text run that consists of the first paragraph text that has been converted to upper case. It then serializes the changed XML into the Open XML package and closes it.

This example uses classes found in the WindowsBase assembly. It uses types in the System.IO.Packaging namespace.

```
public static class LocalExtensions
{
    public static string StringConcatenate(this IEnumerable<string> source)
    {
        StringBuilder sb = new StringBuilder();
        foreach (string s in source)
            sb.Append(s);
        return sb.ToString();
    }

    public static string StringConcatenate<T>(this IEnumerable<T> source,
        Func<T, string> func)
    {
        StringBuilder sb = new StringBuilder();
        foreach (T item in source)
            sb.Append(func(item));
        return sb.ToString();
    }

    public static string StringConcatenate(this IEnumerable<string> source, string separator)
    {
        StringBuilder sb = new StringBuilder();
        foreach (string s in source)
            sb.Append(s).Append(separator);
        return sb.ToString();
    }

    public static string StringConcatenate<T>(this IEnumerable<T> source,
        Func<T, string> func, string separator)
    {
        StringBuilder sb = new StringBuilder();
        foreach (T item in source)
            sb.Append(func(item)).Append(separator);
        return sb.ToString();
    }
}

class Program
{
    public static string ParagraphText(XElement e)
    {
        XNamespace w = e.Name.Namespace;
        return e
               .Elements(w + "r")
```

```
                .Elements(w + "t")
                .StringConcatenate(element => (string)element);
    }

    static void Main(string[] args)
    {
        const string fileName = "SampleDoc.docx";

        const string documentRelationshipType =
          "http://schemas.openxmlformats.org/officeDocument/2006/relationships/officeDocument";
        const string stylesRelationshipType =
          "http://schemas.openxmlformats.org/officeDocument/2006/relationships/styles";
        const string wordmlNamespace =
          "http://schemas.openxmlformats.org/wordprocessingml/2006/main";
        XNamespace w = wordmlNamespace;

        using (Package wdPackage = Package.Open(fileName, FileMode.Open, FileAccess.ReadWrite))
        {
            PackageRelationship docPackageRelationship =
              wdPackage.GetRelationshipsByType(documentRelationshipType).FirstOrDefault();
            if (docPackageRelationship != null)
            {
                Uri documentUri = PackUriHelper.ResolvePartUri(new Uri("/", UriKind.Relative),
                  docPackageRelationship.TargetUri);
                PackagePart documentPart = wdPackage.GetPart(documentUri);

                //  Load the document XML in the part into an XDocument instance.
                XDocument xDoc = XDocument.Load(XmlReader.Create(documentPart.GetStream()));

                //  Find the styles part. There will only be one.
                PackageRelationship styleRelation =
                  documentPart.GetRelationshipsByType(stylesRelationshipType).FirstOrDefault();
                PackagePart stylePart = null;
                XDocument styleDoc = null;

                if (styleRelation != null)
                {
                    Uri styleUri = PackUriHelper.ResolvePartUri(documentUri, styleRelation.TargetUri);
                    stylePart = wdPackage.GetPart(styleUri);

                    //  Load the style XML in the part into an XDocument instance.
                    styleDoc = XDocument.Load(XmlReader.Create(stylePart.GetStream()));
                }

                XElement paraNode = xDoc
                                    .Root
                                    .Element(w + "body")
                                    .Descendants(w + "p")
                                    .FirstOrDefault();

                string paraText = ParagraphText(paraNode);

                // remove all text runs
                paraNode.Descendants(w + "r").Remove();

                paraNode.Add(
                    new XElement(w + "r",
                        new XElement(w + "t", paraText.ToUpper())
                    )
                );

                //  Save the XML into the package
                using (XmlWriter xw =
                  XmlWriter.Create(documentPart.GetStream(FileMode.Create, FileAccess.Write)))
                {
                    xDoc.Save(xw);
                }

                Console.WriteLine("New first paragraph: >{0}<", paraText.ToUpper());
                }
            }
        }
    }
```

If you open `SampleDoc.docx` after running this program, you can see that this program converted the first paragraph in the document to upper case.

When run with the sample Open XML document described in Creating the Source Office Open XML Document (C#), this example produces the following output:

```
New first paragraph: >PARSING WORDPROCESSINGML WITH LINQ TO XML<
```

See also

- Advanced Query Techniques (LINQ to XML) (C#)

How to: Populate an XML Tree from the File System (C#)

1/23/2019 • 2 minutes to read • Edit Online

A common and useful application of XML trees is as a hierarchical name/value data store. You can populate an XML tree with hierarchical data, and then query it, transform it, and if necessary, serialize it. In this usage scenario, many of the XML specific semantics, such as namespaces and white space behavior, are not important. Instead, you are using the XML tree as a small, in memory, single user hierarchical database.

Example

The following example populates an XML tree from the local file system using recursion. It then queries the tree, calculating the total of the sizes of all files in the tree.

```
class Program
{
    static XElement CreateFileSystemXmlTree(string source)
    {
        DirectoryInfo di = new DirectoryInfo(source);
        return new XElement("Dir",
            new XAttribute("Name", di.Name),
            from d in Directory.GetDirectories(source)
            select CreateFileSystemXmlTree(d),
            from fi in di.GetFiles()
            select new XElement("File",
                new XElement("Name", fi.Name),
                new XElement("Length", fi.Length)
            )
        );
    }

    static void Main(string[] args)
    {
        XElement fileSystemTree = CreateFileSystemXmlTree("C:/Tmp");
        Console.WriteLine(fileSystemTree);
        Console.WriteLine("------");
        long totalFileSize =
            (from f in fileSystemTree.Descendants("File")
             select (long)f.Element("Length")).Sum();
        Console.WriteLine("Total File Size:{0}", totalFileSize);
    }
}
```

This example produces output similar to the following:

```
<Dir Name="Tmp">
  <Dir Name="ConsoleApplication1">
    <Dir Name="bin">
      <Dir Name="Debug">
        <File>
          <Name>ConsoleApplication1.exe</Name>
          <Length>4608</Length>
        </File>
        <File>
          <Name>ConsoleApplication1.pdb</Name>
          <Length>11776</Length>
        </File>
        <File>
          <Name>ConsoleApplication1.vshost.exe</Name>
          <Length>9568</Length>
        </File>
        <File>
          <Name>ConsoleApplication1.vshost.exe.manifest</Name>
          <Length>473</Length>
        </File>
      </Dir>
    </Dir>
    <Dir Name="obj">
      <Dir Name="Debug">
        <Dir Name="TempPE" />
        <File>
          <Name>ConsoleApplication1.csproj.FileListAbsolute.txt</Name>
          <Length>322</Length>
        </File>
        <File>
          <Name>ConsoleApplication1.exe</Name>
          <Length>4608</Length>
        </File>
        <File>
          <Name>ConsoleApplication1.pdb</Name>
          <Length>11776</Length>
        </File>
      </Dir>
    </Dir>
    <Dir Name="Properties">
      <File>
        <Name>AssemblyInfo.cs</Name>
        <Length>1454</Length>
      </File>
    </Dir>
    <File>
      <Name>ConsoleApplication1.csproj</Name>
      <Length>2546</Length>
    </File>
    <File>
      <Name>ConsoleApplication1.sln</Name>
      <Length>937</Length>
    </File>
    <File>
      <Name>ConsoleApplication1.suo</Name>
      <Length>10752</Length>
    </File>
    <File>
      <Name>Program.cs</Name>
      <Length>269</Length>
    </File>
  </Dir>
</Dir>
------
Total File Size:59089
```

See also

- Advanced Query Techniques (LINQ to XML) (C#)

LINQ to XML for XPath Users (C#)

1/25/2019 • 3 minutes to read • Edit Online

This set of topics show a number of XPath expressions and their LINQ to XML equivalents.

All of the examples use the XPath functionality in LINQ to XML that is made available by the extension methods in System.Xml.XPath.Extensions. The examples execute both the XPath expression and the LINQ to XML expression. Each example then compares the results of both queries, validating that the XPath expression is functionally equivalent to the LINQ to XML query. As both types of queries return nodes from the same XML tree, the query result comparison is made using referential identity.

In This Section

TOPIC	DESCRIPTION
Comparison of XPath and LINQ to XML	Provides an overview of the similarities and differences between XPath and LINQ to XML.
How to: Find a Child Element (XPath-LINQ to XML) (C#)	Compares the XPath child element axis to the LINQ to XML Element method. The associated XPath expression is: `"DeliveryNotes"`.
How to: Find a List of Child Elements (XPath-LINQ to XML) (C#)	Compares the XPath child elements axis to the LINQ to XML Elements axis. The associated XPath expression is: `"./*"`
How to: Find the Root Element (XPath-LINQ to XML) (C#)	Compares how to get the root element with XPath and LINQ to XML. The associated XPath expression is: `"/PurchaseOrders"`
How to: Find Descendant Elements (XPath-LINQ to XML) (C#)	Compares how to get the descendant elements with a particular name with XPath and LINQ to XML. The associated XPath expression is: `"//Name"`
How to: Filter on an Attribute (XPath-LINQ to XML) (C#)	Compares how to get the descendant elements with a specified name, and with an attribute with a specified value with XPath and LINQ to XML. The associated XPath expression is: `".//Address[@Type='Shipping']"`
How to: Find Related Elements (XPath-LINQ to XML) (C#)	Compares how to get an element selecting on an attribute that is referred to by the value of another element with XPath and LINQ to XML. The associated XPath expression is: `".//Customer[@CustomerID=/Root/Orders/Order[12]/CustomerID]"`

TOPIC	DESCRIPTION
How to: Find Elements in a Namespace (XPath-LINQ to XML) (C#)	Compares the use of the XPath XmlNamespaceManager class with the LINQ to XML Namespace property of the XName class for working with XML namespaces. The associated XPath expression is: `"./aw:*"`
How to: Find Preceding Siblings (XPath-LINQ to XML) (C#)	Compares the XPath `preceding-sibling` axis to the LINQ to XML child XNode.ElementsBeforeSelf axis. The associated XPath expression is: `"preceding-sibling::*"`
How to: Find Descendants of a Child Element (XPath-LINQ to XML) (C#)	Compares how to get the descendant elements of a child element with a particular name with XPath and LINQ to XML. The associated XPath expression is: `"./Paragraph//Text/text()"`
How to: Find a Union of Two Location Paths (XPath-LINQ to XML) (C#)	Compares the use of the union operator, `|`, in XPath with the Concat standard query operator in LINQ to XML. The associated XPath expression is: `"//Category|//Price"`
How to: Find Sibling Nodes (XPath-LINQ to XML) (C#)	Compares how to find all siblings of a node that have a specific name with XPath and LINQ to XML. The associated XPath expression is: `"../Book"`
How to: Find an Attribute of the Parent (XPath-LINQ to XML) (C#)	Compares how to navigate to the parent element and find an associated attribute using XPath and LINQ to XML. The associated XPath expression is: `"../@id"`
How to: Find Attributes of Siblings with a Specific Name (XPath-LINQ to XML) (C#)	Compares how to find specific attributes of the siblings of the context node with XPath and LINQ to XML. The associated XPath expression is: `"../Book/@id"`
How to: Find Elements with a Specific Attribute (XPath-LINQ to XML) (C#)	Compares how to find al elements containing a specific attribute using XPath and LINQ to XML. The associated XPath expression is: `"./*[@Select]"`
How to: Find Child Elements Based on Position (XPath-LINQ to XML) (C#)	Compares how to find an element based on its relative position using XPath and LINQ to XML. The associated XPath expression is: `"Test[position() >= 2 and position() <= 4]"`
How to: Find the Immediate Preceding Sibling (XPath-LINQ to XML) (C#)	Compares how to find the immediate preceding sibling of a node using XPath and LINQ to XML. The associated XPath expression is: `"preceding-sibling::*[1]"`

See also

- System.Xml.XPath
- Querying XML Trees (C#)
- Process XML Data Using the XPath Data Model

Comparison of XPath and LINQ to XML

1/23/2019 • 3 minutes to read • Edit Online

XPath and LINQ to XML offer some similar functionality. Both can be used to query an XML tree, returning such results as a collection of elements, a collection of attributes, a collection of nodes, or the value of an element or attribute. However, there are also some differences.

Differences Between XPath and LINQ to XML

XPath does not allow projection of new types. It can only return collections of nodes from the tree, whereas LINQ to XML can execute a query and project an object graph or an XML tree in a new shape. LINQ to XML queries encompass much more functionality and are much more powerful than XPath expressions.

XPath expressions exist in isolation within a string. The C# compiler cannot help parse the XPath expression at compile time. By contrast, LINQ to XML queries are parsed and compiled by the C# compiler. The compiler is able to catch many query errors.

XPath results are not strongly typed. In a number of circumstances, the result of evaluating an XPath expression is an object, and it is up to the developer to determine the proper type and cast the result as necessary. By contrast, the projections from a LINQ to XML query are strongly typed.

Result Ordering

The XPath 1.0 Recommendation states that a collection that is the result of evaluating an XPath expression is unordered.

However, when iterating through a collection returned by a LINQ to XML XPath axis method, the nodes in the collection are returned in document order. This is the case even when accessing the XPath axes where predicates are expressed in terms of reverse document order, such as `preceding` and `preceding-sibling`.

By contrast, most of the LINQ to XML axes return collections in document order, but two of them, Ancestors and AncestorsAndSelf, return collections in reverse document order. The following table enumerates the axes, and indicates collection order for each:

LINQ TO XML AXIS	ORDERING
XContainer.DescendantNodes	Document order
XContainer.Descendants	Document order
XContainer.Elements	Document order
XContainer.Nodes	Document order
XContainer.NodesAfterSelf	Document order
XContainer.NodesBeforeSelf	Document order
XElement.AncestorsAndSelf	Reverse document order

LINQ TO XML AXIS	ORDERING
XElement.Attributes	Document order
XElement.DescendantNodesAndSelf	Document order
XElement.DescendantsAndSelf	Document order
XNode.Ancestors	Reverse document order
XNode.ElementsAfterSelf	Document order
XNode.ElementsBeforeSelf	Document order
XNode.NodesAfterSelf	Document order
XNode.NodesBeforeSelf	Document order

Positional Predicates

Within an XPath expression, positional predicates are expressed in terms of document order for many axes, but are expressed in reverse document order for reverse axes, which are `preceding`, `preceding-sibling`, `ancestor`, and `ancestor-or-self`. For example, the XPath expression `preceding-sibling::*[1]` returns the immediately preceding sibling. This is the case even though the final result set is presented in document order.

By contrast, all positional predicates in LINQ to XML are always expressed in terms of the order of the axis. For example, `anElement.ElementsBeforeSelf().ElementAt(0)` returns the first child element of the parent of the queried element, not the immediate preceding sibling. Another example: `anElement.Ancestors().ElementAt(0)` returns the parent element.

If you wanted to find the immediately preceding element in LINQ to XML, you would write the following expression:

```
ElementsBeforeSelf().Last()
```

```
ElementsBeforeSelf().Last()
```

Performance Differences

XPath queries that use the XPath functionality in LINQ to XML will not perform as well as LINQ to XML queries.

Comparison of Composition

Composition of a LINQ to XML query is somewhat parallel to composition of an XPath expression, although very different in syntax.

For example, if you have an element in a variable named `customers`, and you want to find a grandchild element named `CompanyName` under all child elements named `Customer`, you would write an XPath expression as follows:

```
customers.XPathSelectElements("./Customer/CompanyName")
customers.XPathSelectElements("./Customer/CompanyName")
```

The equivalent LINQ to XML query is:

```
customers.Elements("Customer").Elements("CompanyName")
```

```
customers.Elements("Customer").Elements("CompanyName")
```

There are similar parallels for each of the XPath axes.

XPATH AXIS	LINQ TO XML AXIS
child (the default axis)	XContainer.Elements
Parent (..)	XObject.Parent
attribute axis (@)	XElement.Attribute or XElement.Attributes
ancestor axis	XNode.Ancestors
ancestor-or-self axis	XElement.AncestorsAndSelf
descendant axis (//)	XContainer.Descendants or XContainer.DescendantNodes
descendant-or-self	XElement.DescendantsAndSelf or XElement.DescendantNodesAndSelf
following-sibling	XNode.ElementsAfterSelf or XNode.NodesAfterSelf
preceding-sibling	XNode.ElementsBeforeSelf or XNode.NodesBeforeSelf
following	No direct equivalent.
preceding	No direct equivalent.

See also

- LINQ to XML for XPath Users (C#)

How to: Find a Child Element (XPath-LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic compares the XPath child element axis to the LINQ to XML Element method.

The XPath expression is `DeliveryNotes`.

Example

This example finds the child element `DeliveryNotes`.

This example uses the following XML document: Sample XML File: Multiple Purchase Orders (LINQ to XML).

```
XDocument cpo = XDocument.Load("PurchaseOrders.xml");
XElement po = cpo.Root.Element("PurchaseOrder");

// LINQ to XML query
XElement el1 = po.Element("DeliveryNotes");

// XPath expression
XElement el2 = po.XPathSelectElement("DeliveryNotes");
// same as "child::DeliveryNotes"
// same as "./DeliveryNotes"

if (el1 == el2)
    Console.WriteLine("Results are identical");
else
    Console.WriteLine("Results differ");
Console.WriteLine(el1);
```

This example produces the following output:

```
Results are identical
<DeliveryNotes>Please leave packages in shed by driveway.</DeliveryNotes>
```

See also

- LINQ to XML for XPath Users (C#)

How to: Find a List of Child Elements (XPath-LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic compares the XPath child elements axis to the LINQ to XML Elements axis.

The XPath expression is: `./*`

Example

This example finds all of the child elements of the `Address` element.

This example uses the following XML document: Sample XML File: Multiple Purchase Orders (LINQ to XML).

```
XDocument cpo = XDocument.Load("PurchaseOrders.xml");
XElement po = cpo.Root.Element("PurchaseOrder").Element("Address");

// LINQ to XML query
IEnumerable<XElement> list1 = po.Elements();

// XPath expression
IEnumerable<XElement> list2 = po.XPathSelectElements("./*");

if (list1.Count() == list2.Count() &&
        list1.Intersect(list2).Count() == list1.Count())
    Console.WriteLine("Results are identical");
else
    Console.WriteLine("Results differ");
foreach (XElement el in list1)
    Console.WriteLine(el);
```

This example produces the following output:

```
Results are identical
<Name>Ellen Adams</Name>
<Street>123 Maple Street</Street>
<City>Mill Valley</City>
<State>CA</State>
<Zip>10999</Zip>
<Country>USA</Country>
```

See also

- LINQ to XML for XPath Users (C#)

How to: Find the Root Element (XPath-LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows how to get the root element with XPath and LINQ to XML.

The XPath expression is:

`/PurchaseOrders`

Example

This example finds the root element.

This example uses the following XML document: Sample XML File: Multiple Purchase Orders (LINQ to XML).

```
XDocument po = XDocument.Load("PurchaseOrders.xml");

// LINQ to XML query
XElement el1 = po.Root;

// XPath expression
XElement el2 = po.XPathSelectElement("/PurchaseOrders");

if (el1 == el2)
    Console.WriteLine("Results are identical");
else
    Console.WriteLine("Results differ");
Console.WriteLine(el1.Name);
```

This example produces the following output:

```
Results are identical
PurchaseOrders
```

See also

- LINQ to XML for XPath Users (C#)

How to: Find Descendant Elements (XPath-LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows how to get the descendant elements with a particular name.

The XPath expression is `//Name`.

Example

This example finds all descendants named `Name`.

This example uses the following XML document: Sample XML File: Multiple Purchase Orders (LINQ to XML).

```
XDocument po = XDocument.Load("PurchaseOrders.xml");

// LINQ to XML query
IEnumerable<XElement> list1 = po.Root.Descendants("Name");

// XPath expression
IEnumerable<XElement> list2 = po.XPathSelectElements("//Name");

if (list1.Count() == list2.Count() &&
        list1.Intersect(list2).Count() == list1.Count())
    Console.WriteLine("Results are identical");
else
    Console.WriteLine("Results differ");
foreach (XElement el in list1)
    Console.WriteLine(el);
```

This example produces the following output:

```
Results are identical
<Name>Ellen Adams</Name>
<Name>Tai Yee</Name>
<Name>Cristian Osorio</Name>
<Name>Cristian Osorio</Name>
<Name>Jessica Arnold</Name>
<Name>Jessica Arnold</Name>
```

See also

- LINQ to XML for XPath Users (C#)

How to: Filter on an Attribute (XPath-LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows how to get the descendant elements with a specified name, and with an attribute with a specified value.

The XPath expression is:

`.//Address[@Type='Shipping']`

Example

This example finds all descendants elements with the name of `Address`, and with a `Type` attribute with a value of "Shipping".

This example uses the following XML document: Sample XML File: Multiple Purchase Orders (LINQ to XML).

```
XDocument po = XDocument.Load("PurchaseOrders.xml");

// LINQ to XML query
IEnumerable<XElement> list1 =
    from el in po.Descendants("Address")
    where (string)el.Attribute("Type") == "Shipping"
    select el;

// XPath expression
IEnumerable<XElement> list2 = po.XPathSelectElements(".//Address[@Type='Shipping']");

if (list1.Count() == list2.Count() &&
        list1.Intersect(list2).Count() == list1.Count())
    Console.WriteLine("Results are identical");
else
    Console.WriteLine("Results differ");
foreach (XElement el in list1)
    Console.WriteLine(el);
```

This example produces the following output:

```
Results are identical
<Address Type="Shipping">
  <Name>Ellen Adams</Name>
  <Street>123 Maple Street</Street>
  <City>Mill Valley</City>
  <State>CA</State>
  <Zip>10999</Zip>
  <Country>USA</Country>
</Address>
<Address Type="Shipping">
  <Name>Cristian Osorio</Name>
  <Street>456 Main Street</Street>
  <City>Buffalo</City>
  <State>NY</State>
  <Zip>98112</Zip>
  <Country>USA</Country>
</Address>
<Address Type="Shipping">
  <Name>Jessica Arnold</Name>
  <Street>4055 Madison Ave</Street>
  <City>Seattle</City>
  <State>WA</State>
  <Zip>98112</Zip>
  <Country>USA</Country>
</Address>
```

See also

- LINQ to XML for XPath Users (C#)

How to: Find Related Elements (XPath-LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows how to get an element selecting on an attribute that is referred to by the value of another element.

The XPath expression is:

```
.//Customer[@CustomerID=/Root/Orders/Order[12]/CustomerID]
```

Example

This example finds the 12th `Order` element, and then finds the customer for that order.

Note that indexing into a list in .Net is 'zero' based. Indexing into a collection of nodes in an XPath predicate is 'one' based. This example reflects this difference.

This example uses the following XML document: Sample XML File: Customers and Orders (LINQ to XML).

```
XDocument co = XDocument.Load("CustomersOrders.xml");

// LINQ to XML query
XElement customer1 =
    (from el in co.Descendants("Customer")
     where (string)el.Attribute("CustomerID") ==
          (string)(co
              .Element("Root")
              .Element("Orders")
              .Elements("Order")
              .ToList()[11]
              .Element("CustomerID"))
    select el)
    .First();

// An alternate way to write the query that avoids creation
// of a System.Collections.Generic.List:
XElement customer2 =
    (from el in co.Descendants("Customer")
     where (string)el.Attribute("CustomerID") ==
          (string)(co
              .Element("Root")
              .Element("Orders")
              .Elements("Order")
              .Skip(11).First()
              .Element("CustomerID"))
    select el)
    .First();

// XPath expression
XElement customer3 = co.XPathSelectElement(
  ".//Customer[@CustomerID=/Root/Orders/Order[12]/CustomerID]");

if (customer1 == customer2 && customer1 == customer3)
    Console.WriteLine("Results are identical");
else
    Console.WriteLine("Results differ");
Console.WriteLine(customer1);
```

This example produces the following output:

```
Results are identical
<Customer CustomerID="HUNGC">
  <CompanyName>Hungry Coyote Import Store</CompanyName>
  <ContactName>Yoshi Latimer</ContactName>
  <ContactTitle>Sales Representative</ContactTitle>
  <Phone>(503) 555-6874</Phone>
  <Fax>(503) 555-2376</Fax>
  <FullAddress>
    <Address>City Center Plaza 516 Main St.</Address>
    <City>Elgin</City>
    <Region>OR</Region>
    <PostalCode>97827</PostalCode>
    <Country>USA</Country>
  </FullAddress>
</Customer>
```

See also

- LINQ to XML for XPath Users (C#)

How to: Find Elements in a Namespace (XPath-LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

XPath expressions can find nodes in a particular namespace. XPath expressions use namespace prefixes for specifying namespaces. To parse an XPath expression that contains namespace prefixes, you must pass an object to the XPath methods that implements IXmlNamespaceResolver. This example uses XmlNamespaceManager.

The XPath expression is:

`./aw:*`

Example

The following example reads an XML tree that contains two namespaces. It uses an XmlReader to read the XML document. It then gets an XmlNameTable from the XmlReader, and an XmlNamespaceManager from the XmlNameTable. It uses the XmlNamespaceManager when selecting elements.

```
XmlReader reader = XmlReader.Create("ConsolidatedPurchaseOrders.xml");
XElement root = XElement.Load(reader);
XmlNameTable nameTable = reader.NameTable;
XmlNamespaceManager namespaceManager = new XmlNamespaceManager(nameTable);
namespaceManager.AddNamespace("aw", "http://www.adventure-works.com");
IEnumerable<XElement> list1 = root.XPathSelectElements("./aw:*", namespaceManager);
IEnumerable<XElement> list2 =
    from el in root.Elements()
    where el.Name.Namespace == "http://www.adventure-works.com"
    select el;
if (list1.Count() == list2.Count() &&
        list1.Intersect(list2).Count() == list1.Count())
    Console.WriteLine("Results are identical");
else
    Console.WriteLine("Results differ");
foreach (XElement el in list2)
    Console.WriteLine(el);
```

This example produces the following output:

```
Results are identical
<aw:PurchaseOrder PONumber="11223" Date="2000-01-15" xmlns:aw="http://www.adventure-works.com">
    <aw:ShippingAddress>
      <aw:Name>Chris Preston</aw:Name>
      <aw:Street>123 Main St.</aw:Street>
      <aw:City>Seattle</aw:City>
      <aw:State>WA</aw:State>
      <aw:Zip>98113</aw:Zip>
      <aw:Country>USA</aw:Country>
    </aw:ShippingAddress>
    <aw:BillingAddress>
      <aw:Name>Chris Preston</aw:Name>
      <aw:Street>123 Main St.</aw:Street>
      <aw:City>Seattle</aw:City>
      <aw:State>WA</aw:State>
      <aw:Zip>98113</aw:Zip>
      <aw:Country>USA</aw:Country>
    </aw:BillingAddress>
    <aw:DeliveryInstructions>Ship only complete order.</aw:DeliveryInstructions>
    <aw:Item PartNum="LIT-01">
      <aw:ProductID>Litware Networking Card</aw:ProductID>
      <aw:Qty>1</aw:Qty>
      <aw:Price>20.99</aw:Price>
    </aw:Item>
    <aw:Item PartNum="LIT-25">
      <aw:ProductID>Litware 17in LCD Monitor</aw:ProductID>
      <aw:Qty>1</aw:Qty>
      <aw:Price>199.99</aw:Price>
    </aw:Item>
  </aw:PurchaseOrder>
```

See also

- LINQ to XML for XPath Users (C#)

How to: Find Preceding Siblings (XPath-LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic compares the XPath `preceding-sibling` axis to the LINQ to XML child XNode.ElementsBeforeSelf axis.

The XPath expression is:

`preceding-sibling::*`

Note that the results of both XPathSelectElements and XNode.ElementsBeforeSelf are in document order.

Example

The following example finds the `FullAddress` element, and then retrieves the previous elements using the `preceding-sibling` axis.

This example uses the following XML document: Sample XML File: Customers and Orders (LINQ to XML).

```
XElement co = XElement.Load("CustomersOrders.xml");

XElement add = co.Element("Customers").Element("Customer").Element("FullAddress");

// LINQ to XML query
IEnumerable<XElement> list1 = add.ElementsBeforeSelf();

// XPath expression
IEnumerable<XElement> list2 = add.XPathSelectElements("preceding-sibling::*");

if (list1.Count() == list2.Count() &&
        list1.Intersect(list2).Count() == list1.Count())
    Console.WriteLine("Results are identical");
else
    Console.WriteLine("Results differ");
foreach (XElement el in list2)
    Console.WriteLine(el);
```

This example produces the following output:

```
Results are identical
<CompanyName>Great Lakes Food Market</CompanyName>
<ContactName>Howard Snyder</ContactName>
<ContactTitle>Marketing Manager</ContactTitle>
<Phone>(503) 555-7555</Phone>
```

See also

- LINQ to XML for XPath Users (C#)

How to: Find Descendants of a Child Element (XPath-LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows how to get the descendant elements of a child element with a particular name.

The XPath expression is:

`./Paragraph//Text/text()`

Example

This example simulates the problems of extracting text from an XML representation of a word processing document. It first selects all `Paragraph` elements, and then it selects all `Text` descendant elements of each `Paragraph` element. This doesn't select the descendant `Text` elements of the `Comment` element.

```
XElement root = XElement.Parse(
@"<Root>
  <Paragraph>
    <Text>This is the start of</Text>
  </Paragraph>
  <Comment>
    <Text>This comment is not part of the paragraph text.</Text>
  </Comment>
  <Paragraph>
    <Annotation Emphasis='true'>
      <Text> a sentence.</Text>
    </Annotation>
  </Paragraph>
  <Paragraph>
    <Text>  This is a second sentence.</Text>
  </Paragraph>
</Root>");

// LINQ to XML query
string str1 =
    root
    .Elements("Paragraph")
    .Descendants("Text")
    .Select(s => s.Value)
    .Aggregate(
        new StringBuilder(),
        (s, i) => s.Append(i),
        s => s.ToString()
    );

// XPath expression
string str2 =
    ((IEnumerable)root.XPathEvaluate("./Paragraph//Text/text()"))
    .Cast<XText>()
    .Select(s => s.Value)
    .Aggregate(
        new StringBuilder(),
        (s, i) => s.Append(i),
        s => s.ToString()
    );

if (str1 == str2)
    Console.WriteLine("Results are identical");
else
    Console.WriteLine("Results differ");
Console.WriteLine(str2);
```

This example produces the following output:

```
Results are identical
This is the start of a sentence.  This is a second sentence.
```

See also

- LINQ to XML for XPath Users (C#)

How to: Find a Union of Two Location Paths (XPath-LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

XPath allows you to find the union of the results of two XPath location paths.

The XPath expression is:

`//Category|//Price`

You can achieve the same results by using the Concat standard query operator.

Example

This example finds all of the `Category` elements and all of the `Price` elements, and concatenates them into a single collection. Note that the LINQ to XML query calls InDocumentOrder to order the results. The results of the XPath expression evaluation are also in document order.

This example uses the following XML document: Sample XML File: Numerical Data (LINQ to XML).

```
XDocument data = XDocument.Load("Data.xml");

// LINQ to XML query
IEnumerable<XElement> list1 =
    data
    .Descendants("Category")
    .Concat(
        data
        .Descendants("Price")
    )
    .InDocumentOrder();

// XPath expression
IEnumerable<XElement> list2 = data.XPathSelectElements("//Category|//Price");

if (list1.Count() == list2.Count() &&
        list1.Intersect(list2).Count() == list1.Count())
    Console.WriteLine("Results are identical");
else
    Console.WriteLine("Results differ");
foreach (XElement el in list1)
    Console.WriteLine(el);
```

This example produces the following output:

```
Results are identical
<Category>A</Category>
<Price>24.50</Price>
<Category>B</Category>
<Price>89.99</Price>
<Category>A</Category>
<Price>4.95</Price>
<Category>A</Category>
<Price>66.00</Price>
<Category>B</Category>
<Price>.99</Price>
<Category>A</Category>
<Price>29.00</Price>
<Category>B</Category>
<Price>6.99</Price>
```

See also

- LINQ to XML for XPath Users (C#)

How to: Find Sibling Nodes (XPath-LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

You might want to find all siblings of a node that have a specific name. The resulting collection might include the context node if the context node also has the specific name.

The XPath expression is:

`../Book`

Example

This example first finds a `Book` element, and then finds all sibling elements named `Book`. The resulting collection includes the context node.

This example uses the following XML document: Sample XML File: Books (LINQ to XML).

```
XDocument books = XDocument.Load("Books.xml");

XElement book =
    books
    .Root
    .Elements("Book")
    .Skip(1)
    .First();

// LINQ to XML query
IEnumerable<XElement> list1 =
    book
    .Parent
    .Elements("Book");

// XPath expression
IEnumerable<XElement> list2 = book.XPathSelectElements("../Book");

if (list1.Count() == list2.Count() &&
        list1.Intersect(list2).Count() == list1.Count())
    Console.WriteLine("Results are identical");
else
    Console.WriteLine("Results differ");
foreach (XElement el in list1)
    Console.WriteLine(el);
```

This example produces the following output:

```
Results are identical
<Book id="bk101">
  <Author>Garghentini, Davide</Author>
  <Title>XML Developer's Guide</Title>
  <Genre>Computer</Genre>
  <Price>44.95</Price>
  <PublishDate>2000-10-01</PublishDate>
  <Description>An in-depth look at creating applications
      with XML.</Description>
</Book>
<Book id="bk102">
  <Author>Garcia, Debra</Author>
  <Title>Midnight Rain</Title>
  <Genre>Fantasy</Genre>
  <Price>5.95</Price>
  <PublishDate>2000-12-16</PublishDate>
  <Description>A former architect battles corporate zombies,
      an evil sorceress, and her own childhood to become queen
      of the world.</Description>
</Book>
```

See also

- LINQ to XML for XPath Users (C#)

How to: Find an Attribute of the Parent (XPath-LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows how to navigate to the parent element and find an attribute of it.

The XPath expression is:

`../@id`

Example

This example first finds an `Author` element. It then finds the `id` attribute of the parent element.

This example uses the following XML document: Sample XML File: Books (LINQ to XML).

```
XDocument books = XDocument.Load("Books.xml");

XElement author =
    books
    .Root
    .Element("Book")
    .Element("Author");

// LINQ to XML query
XAttribute att1 =
    author
    .Parent
    .Attribute("id");

// XPath expression
XAttribute att2 = ((IEnumerable)author.XPathEvaluate("../@id")).Cast<XAttribute>().First();

if (att1 == att2)
    Console.WriteLine("Results are identical");
else
    Console.WriteLine("Results differ");
Console.WriteLine(att1);
```

This example produces the following output:

```
Results are identical
id="bk101"
```

See also

- LINQ to XML for XPath Users (C#)

How to: Find Attributes of Siblings with a Specific Name (XPath-LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows how to find all attributes of the siblings of the context node. Only attributes with a specific name are returned in the collection.

The XPath expression is:

`../Book/@id`

Example

This example first finds a `Book` element, and then finds all sibling elements named `Book`, and then finds all attributes named `id`. The result is a collection of attributes.

This example uses the following XML document: Sample XML File: Books (LINQ to XML).

```
XDocument books = XDocument.Load("Books.xml");

XElement book =
    books
    .Root
    .Element("Book");

// LINQ to XML query
IEnumerable<XAttribute> list1 =
    from el in book.Parent.Elements("Book")
    select el.Attribute("id");

// XPath expression
IEnumerable<XAttribute> list2 =
  ((IEnumerable)book.XPathEvaluate("../Book/@id")).Cast<XAttribute>();

if (list1.Count() == list2.Count() &&
        list1.Intersect(list2).Count() == list1.Count())
    Console.WriteLine("Results are identical");
else
    Console.WriteLine("Results differ");
foreach (XAttribute el in list1)
    Console.WriteLine(el);
```

This example produces the following output:

```
Results are identical
id="bk101"
id="bk102"
```

See also

- LINQ to XML for XPath Users (C#)

How to: Find Elements with a Specific Attribute (XPath-LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

Sometimes you want to find all elements that have a specific attribute. You are not concerned about the contents of the attribute. Instead, you want to select based on the existence of the attribute.

The XPath expression is:

`./*[@Select]`

Example

The following code selects just the elements that have the `Select` attribute.

```
XElement doc = XElement.Parse(
@"<Root>
    <Child1>1</Child1>
    <Child2 Select='true'>2</Child2>
    <Child3>3</Child3>
    <Child4 Select='true'>4</Child4>
    <Child5>5</Child5>
</Root>");

// LINQ to XML query
IEnumerable<XElement> list1 =
    from el in doc.Elements()
    where el.Attribute("Select") != null
    select el;

// XPath expression
IEnumerable<XElement> list2 =
    ((IEnumerable)doc.XPathEvaluate("./*[@Select]")).Cast<XElement>();

if (list1.Count() == list2.Count() &&
        list1.Intersect(list2).Count() == list1.Count())
    Console.WriteLine("Results are identical");
else
    Console.WriteLine("Results differ");
foreach (XElement el in list1)
    Console.WriteLine(el);
```

This example produces the following output:

```
Results are identical
<Child2 Select="true">2</Child2>
<Child4 Select="true">4</Child4>
```

See also

- LINQ to XML for XPath Users (C#)

How to: Find Child Elements Based on Position (XPath-LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

Sometimes you want to find elements based on their position. You might want to find the second element, or you might want to find the third through the fifth element.

The XPath expression is:

`Test[position() >= 2 and position() <= 4]`

There are two approaches to writing this LINQ to XML query in a lazy way. You can use the Skip and Take operators, or you can use the Where overload that takes an index. When you use the Where overload, you use a lambda expression that takes two arguments. The following example shows both methods of selecting based on position.

Example

This example finds the second through the fourth `Test` element. The result is a collection of elements.

This example uses the following XML document: Sample XML File: Test Configuration (LINQ to XML).

```
XElement testCfg = XElement.Load("TestConfig.xml");

// LINQ to XML query
IEnumerable<XElement> list1 =
    testCfg
    .Elements("Test")
    .Skip(1)
    .Take(3);

// LINQ to XML query
IEnumerable<XElement> list2 =
    testCfg
    .Elements("Test")
    .Where((el, idx) => idx >= 1 && idx <= 3);

// XPath expression
IEnumerable<XElement> list3 =
  testCfg.XPathSelectElements("Test[position() >= 2 and position() <= 4]");

if (list1.Count() == list2.Count() &&
    list1.Count() == list3.Count() &&
    list1.Intersect(list2).Count() == list1.Count() &&
    list1.Intersect(list3).Count() == list1.Count())
    Console.WriteLine("Results are identical");
else
    Console.WriteLine("Results differ");
foreach (XElement el in list1)
    Console.WriteLine(el);
```

This example produces the following output:

```
Results are identical
<Test TestId="0002" TestType="CMD">
  <Name>Find succeeding characters</Name>
  <CommandLine>Examp2.EXE</CommandLine>
  <Input>abc</Input>
  <Output>def</Output>
</Test>
<Test TestId="0003" TestType="GUI">
  <Name>Convert multiple numbers to strings</Name>
  <CommandLine>Examp2.EXE /Verbose</CommandLine>
  <Input>123</Input>
  <Output>One Two Three</Output>
</Test>
<Test TestId="0004" TestType="GUI">
  <Name>Find correlated key</Name>
  <CommandLine>Examp3.EXE</CommandLine>
  <Input>a1</Input>
  <Output>b1</Output>
</Test>
```

See also

- LINQ to XML for XPath Users (C#)

How to: Find the Immediate Preceding Sibling (XPath-LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

Sometimes you want to find the immediate preceding sibling to a node. Due to the difference in the semantics of positional predicates for the preceding sibling axes in XPath as opposed to LINQ to XML, this is one of the more interesting comparisons.

Example

In this example, the LINQ to XML query uses the Last operator to find the last node in the collection returned by ElementsBeforeSelf. By contrast, the XPath expression uses a predicate with a value of 1 to find the immediately preceding element.

```
XElement root = XElement.Parse(
    @"<Root>
    <Child1/>
    <Child2/>
    <Child3/>
    <Child4/>
</Root>");
XElement child4 = root.Element("Child4");

// LINQ to XML query
XElement el1 =
    child4
    .ElementsBeforeSelf()
    .Last();

// XPath expression
XElement el2 =
    ((IEnumerable)child4
                 .XPathEvaluate("preceding-sibling::*[1]"))
                 .Cast<XElement>()
                 .First();

if (el1 == el2)
    Console.WriteLine("Results are identical");
else
    Console.WriteLine("Results differ");
Console.WriteLine(el1);
```

This example produces the following output:

```
Results are identical
<Child3 />
```

See also

- LINQ to XML for XPath Users (C#)

Pure Functional Transformations of XML (C#)

1/23/2019 • 2 minutes to read • Edit Online

This section provides a functional transformation tutorial for XML. This includes explanations of the main concepts and language constructs that you must understand to use functional transformations, and examples of using functional transformations to manipulate an XML document. Although this tutorial provides LINQ to XML code examples, all of the underlying concepts also apply to other LINQ technologies.

The Tutorial: Manipulating Content in a WordprocessingML Document (C#) tutorial provides a series of examples, each building on the previous one. These examples demonstrate the pure functional transformational approach to manipulating XML.

This tutorial assumes a working knowledge of C#. Detailed semantics of the language constructs are not provided in this tutorial, but links are provided to the language documentation as appropriate.

A working knowledge of basic computer science concepts and XML, including XML namespaces, is also assumed.

In This Section

TOPIC	DESCRIPTION
Introduction to Pure Functional Transformations (C#)	Describes functional transformations and defines the relevant terminology.
Tutorial: Chaining Queries Together (C#)	Describes lazy evaluation and deferred execution in detail.
Tutorial: Manipulating Content in a WordprocessingML Document (C#)	A tutorial that demonstrates a functional transformation.

See also

- Querying XML Trees (C#)

Introduction to Pure Functional Transformations (C#)

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This section introduces functional transformations, including the underlying concepts and supporting language constructs. It contrasts the object-oriented and functional transformation approaches to programming, including advice on how to transition to the latter. Although functional transformations can be used in many programming scenarios, XML transformation is used here as a concrete example.

In This Section

TOPIC	DESCRIPTION
Concepts and Terminology (Functional Transformation) (C#)	Introduces the concepts and terminology of pure functional transformations.
Functional Programming vs. Imperative Programming (C#)	Compares and contrasts functional programming to more traditional imperative (procedural) programming.
Refactoring Into Pure Functions (C#)	Introduces pure functions, and shows examples of and pure and impure functions.
Applicability of Functional Transformation (C#)	Describes typical scenarios for functional transformations.
Functional Transformation of XML (Visual Basic)	Describes functional transformations in the context of transforming XML trees.

See also

- Pure Functional Transformations of XML (C#)

Concepts and Terminology (Functional Transformation) (C#)

1/23/2019 • 3 minutes to read • Edit Online

This topic introduces the concepts and terminology of pure functional transformations. The functional transformation approach to transforming data yields code that is often quicker to program, more expressive, and easier to debug and maintain than more traditional, imperative programming.

Note that the topics in this section are not intended to fully explain functional programming. Instead, these topics identify some of the functional programming capabilities that make it easier to transform XML from one shape to another.

What Is Pure Functional Transformation?

In *pure functional transformation*, a set of functions, called *pure functions*, define how to transform a set of structured data from its original form into another form. The word "pure" indicates that the functions are *composable*, which requires that they are:

- *Self-contained*, so that they can be freely ordered and rearranged without entanglement or interdependencies with the rest of the program. Pure transformations have no knowledge of or effect upon their environment. That is, the functions used in the transformation have no *side effects*.
- *Stateless*, so that executing the same function or specific set of functions on the same input will always result in the same output. Pure transformations have no memory of their prior use.

IMPORTANT

In the rest of this tutorial, the term "pure function" is used in a general sense to indicate a programming approach, and not a specific language feature.

Note that pure functions must be implemented as methods in C#.

Also, you should not confuse pure functions with pure virtual methods in C++. The latter indicates that the containing class is abstract and that no method body is supplied.

Functional Programming

Functional programming is a programming approach that directly supports pure functional transformation.

Historically, general-purpose functional programming languages, such as ML, Scheme, Haskell, and F#, have been primarily of interest to the academic community. Although it has always been possible to write pure functional transformations in C#, the difficulty of doing so has not made it an attractive option to most programmers. In recent versions of C#, however, new language constructs such as lambda expressions and type inference make it functional programming much easier and more productive.

For more information about functional programming, see Functional Programming vs. Imperative Programming (C#).

Domain-Specific FP Languages

Although general functional programming languages have not been widely adopted, specific domain-specific functional programming languages have had better success. For example, Cascading Style Sheets (CSS) are used to determine the look and feel of many Web pages, and Extensible Stylesheet Language Transformations (XSLT) style sheets are used extensively in XML data manipulation. For more information about XSLT, see XSLT

Transformations.

Terminology

The following table defines some terms related to functional transformations.

higher-order (first-class) function
A function that can be treated as a programmatic object. For example, a higher-order function can be passed to or returned from other functions. In C#c, delegates and lambda expressions are language features that support higher-order functions. To write a higher-order function, you declare one or more arguments to take delegates, and you often use lambda expressions when calling it. Many of the standard query operators are higher-order functions.

For more information, see Standard Query Operators Overview (C#).

lambda expression
Essentially, an inline anonymous function that can be used wherever a delegate type is expected. This is a simplified definition of lambda expressions, but it is adequate for the purposes of this tutorial.

For more information about, see Lambda Expressions.

collection
A structured set of data, usually of a uniform type. To be compatible with LINQ, a collection must implement the IEnumerable interface or the IQueryable interface (or one of their generic counterparts, IEnumerator<T> or IQueryable<T>).

tuple (anonymous types)
A mathematical concept, a tuple is a finite sequence of objects, each of a specific type. A tuple is also known as an ordered list. Anonymous types are a language implementation of this concept, which enable an unnamed class type to be declared and an object of that type to be instantiated at the same time.

For more information, see Anonymous Types.

type inference (implicit typing)
The ability of a compiler to determine the type of a variable in the absence of an explicit type declaration.

For more information, see Implicitly Typed Local Variables.

deferred execution and lazy evaluation
The delaying of evaluation of an expression until its resolved value is actually required. Deferred execution is supported in collections.

For more information, see Introduction to LINQ Queries (C#) and Deferred Execution and Lazy Evaluation in LINQ to XML (C#).

These language features will be used in code samples throughout this section.

See also

- Introduction to Pure Functional Transformations (C#)
- Functional Programming vs. Imperative Programming (C#)

Functional Programming vs. Imperative Programming (C#)

1/23/2019 • 3 minutes to read • Edit Online

This topic compares and contrasts functional programming with more traditional imperative (procedural) programming.

Functional Programming vs. Imperative Programming

The *functional programming* paradigm was explicitly created to support a pure functional approach to problem solving. Functional programming is a form of *declarative programming*. In contrast, most mainstream languages, including object-oriented programming (OOP) languages such as C#, Visual Basic, C++, and Java, were designed to primarily support *imperative* (procedural) programming.

With an imperative approach, a developer writes code that describes in exacting detail the steps that the computer must take to accomplish the goal. This is sometimes referred to as *algorithmic* programming. In contrast, a functional approach involves composing the problem as a set of functions to be executed. You define carefully the input to each function, and what each function returns. The following table describes some of the general differences between these two approaches.

CHARACTERISTIC	IMPERATIVE APPROACH	FUNCTIONAL APPROACH
Programmer focus	How to perform tasks (algorithms) and how to track changes in state.	What information is desired and what transformations are required.
State changes	Important.	Non-existent.
Order of execution	Important.	Low importance.
Primary flow control	Loops, conditionals, and function (method) calls.	Function calls, including recursion.
Primary manipulation unit	Instances of structures or classes.	Functions as first-class objects and data collections.

Although most languages were designed to support a specific programming paradigm, many general languages are flexible enough to support multiple paradigms. For example, most languages that contain function pointers can be used to credibly support functional programming. Furthermore, C# includes explicit language extensions to support functional programming, including lambda expressions and type inference. LINQ technology is a form of declarative, functional programming.

Functional Programming Using XSLT

Many XSLT developers are familiar with the pure functional approach. The most effective way to develop an XSLT style sheet is to treat each template as an isolated, composable transformation. The order of execution is completely de-emphasized. XSLT does not allow side effects (with the exception that escaping mechanisms for executing procedural code can introduce side effects that result in functional impurity). However, although XSLT is an effective tool, some of its characteristics are not optimal. For example, expressing programming constructs in XML makes code relatively verbose, and therefore difficult to maintain. Also, the heavy reliance on recursion for flow control can result in code that is hard to read. For more information about XSLT, see XSLT Transformations.

However, XSLT has proved the value of using a pure functional approach for transforming XML from one shape to another. Pure functional programming with LINQ to XML is similar in many ways to XSLT. However, the programming constructs introduced by LINQ to XML and C# allow you to write pure functional transformations that are more readable and maintainable than XSLT.

Advantages of Pure Functions

The primary reason to implement functional transformations as pure functions is that pure functions are composable: that is, self-contained and stateless. These characteristics bring a number of benefits, including the following:

- Increased readability and maintainability. This is because each function is designed to accomplish a specific task given its arguments. The function does not rely on any external state.
- Easier reiterative development. Because the code is easier to refactor, changes to design are often easier to implement. For example, suppose you write a complicated transformation, and then realize that some code is repeated several times in the transformation. If you refactor through a pure method, you can call your pure method at will without worrying about side effects.
- Easier testing and debugging. Because pure functions can more easily be tested in isolation, you can write test code that calls the pure function with typical values, valid edge cases, and invalid edge cases.

Transitioning for OOP Developers

In traditional object-oriented programming (OOP), most developers are accustomed to programming in the imperative/procedural style. To switch to developing in a pure functional style, they have to make a transition in their thinking and their approach to development.

To solve problems, OOP developers design class hierarchies, focus on proper encapsulation, and think in terms of class contracts. The behavior and state of object types are paramount, and language features, such as classes, interfaces, inheritance, and polymorphism, are provided to address these concerns.

In contrast, functional programming approaches computational problems as an exercise in the evaluation of pure functional transformations of data collections. Functional programming avoids state and mutable data, and instead emphasizes the application of functions.

Fortunately, C# doesn't require the full leap to functional programming, because it supports both imperative and functional programming approaches. A developer can choose which approach is most appropriate for a particular scenario. In fact, programs often combine both approaches.

See also

- Introduction to Pure Functional Transformations (C#)
- XSLT Transformations
- Refactoring Into Pure Functions (C#)

Refactoring Into Pure Functions (C#)

1/23/2019 • 3 minutes to read • Edit Online

An important aspect of pure functional transformations is learning how to refactor code using pure functions.

NOTE

The common nomenclature in functional programming is that you refactor programs using pure functions. In Visual Basic and C++, this aligns with the use of functions in the respective languages. However, in C#, functions are called methods. For the purposes of this discussion, a pure function is implemented as a method in C#.

As noted previously in this section, a pure function has two useful characteristics:

- It has no side effects. The function does not change any variables or the data of any type outside of the function.
- It is consistent. Given the same set of input data, it will always return the same output value.

One way of transitioning to functional programming is to refactor existing code to eliminate unnecessary side effects and external dependencies. In this way, you can create pure function versions of existing code.

This topic discusses what a pure function is and what it is not. The Tutorial: Manipulating Content in a WordprocessingML Document (C#) tutorial shows how to manipulate a WordprocessingML document, and includes two examples of how to refactor using a pure function.

Eliminating Side Effects and External Dependencies

The following examples contrast two non-pure functions and a pure function.

Non-Pure Function that Changes a Class Member

In the following code, the `HyphenatedConcat` function is not a pure function, because it modifies the `aMember` data member in the class:

```
public class Program
{
    private static string aMember = "StringOne";

    public static void HyphenatedConcat(string appendStr)
    {
        aMember += '-' + appendStr;
    }

    public static void Main()
    {
        HyphenatedConcat("StringTwo");
        Console.WriteLine(aMember);
    }
}
```

This code produces the following output:

```
StringOne-StringTwo
```

Note that it is irrelevant whether the data being modified has `public` or `private` access, or is a `static` member or an instance member. A pure function does not change any data outside of the function.

Non-Pure Function that Changes an Argument

Furthermore, the following version of this same function is not pure because it modifies the contents of its parameter, `sb`.

```
public class Program
{
    public static void HyphenatedConcat(StringBuilder sb, String appendStr)
    {
        sb.Append('-' + appendStr);
    }

    public static void Main()
    {
        StringBuilder sb1 = new StringBuilder("StringOne");
        HyphenatedConcat(sb1, "StringTwo");
        Console.WriteLine(sb1);
    }
}
```

This version of the program produces the same output as the first version, because the `HyphenatedConcat` function has changed the value (state) of its first parameter by invoking the Append member function. Note that this alteration occurs despite that fact that `HyphenatedConcat` uses call-by-value parameter passing.

IMPORTANT

For reference types, if you pass a parameter by value, it results in a copy of the reference to an object being passed. This copy is still associated with the same instance data as the original reference (until the reference variable is assigned to a new object). Call-by-reference is not necessarily required for a function to modify a parameter.

Pure Function

This next version of the program shows how to implement the `HyphenatedConcat` function as a pure function.

```
class Program
{
    public static string HyphenatedConcat(string s, string appendStr)
    {
        return (s + '-' + appendStr);
    }

    public static void Main(string[] args)
    {
        string s1 = "StringOne";
        string s2 = HyphenatedConcat(s1, "StringTwo");
        Console.WriteLine(s2);
    }
}
```

Again, this version produces the same line of output: `StringOne-StringTwo`. Note that to retain the concatenated value, it is stored in the intermediate variable `s2`.

One approach that can be very useful is to write functions that are locally impure (that is, they declare and modify local variables) but are globally pure. Such functions have many of the desirable composability characteristics, but avoid some of the more convoluted functional programming idioms, such as having to use recursion when a simple loop would accomplish the same thing.

Standard Query Operators

An important characteristic of the standard query operators is that they are implemented as pure functions.

For more information, see Standard Query Operators Overview (C#).

See also

- Introduction to Pure Functional Transformations (C#)
- Functional Programming vs. Imperative Programming (C#)

Applicability of Functional Transformation (C#)

1/23/2019 • 2 minutes to read • Edit Online

Pure functional transformations are applicable in a wide variety of situations.

The functional transformation approach is ideally suited for querying and manipulating structured data; therefore it fits well with LINQ technologies. However, functional transformation has a much wider applicability than use with LINQ. Any process where the main focus is on transforming data from one form to another should probably be considered as a candidate for functional transformation.

This approach is applicable to many problems that might not appear at first glance to be a candidate. Used in conjunction with or separately from LINQ, functional transformation should be considered for the following areas:

- XML-based documents. Well-formed data of any XML dialect can be easily manipulated through functional transformation. For more information, see Functional Transformation of XML (C#).
- Other structured file formats. From Windows.ini files to plain text documents, most files have some structure that lends itself to analysis and transformation.
- Data streaming protocols. Encoding data into and decoding data from communication protocols can often be represented by a simple functional transform.
- RDBMS and OODBMS data. Relational and object-oriented databases, just like XML, are widely-used structured data sources.
- Mathematic, statistic, and science solutions. These fields tend to manipulate large data sets to assist the user in visualizing, estimating, or actually solving non-trivial problems.

As described in Refactoring Into Pure Functions (C#), using pure functions is an example of functional programming. In additional to their immediate benefits, using pure functions provides valuable experience in thinking about problems from a functional transformation perspective. This approach can also have major impact on program and class design. This is especially true when a problem lends itself to a data transformation solution as described above.

Although they are beyond the scope of this tutorial, designs that are influenced by the functional transformation perspective tend to center on processes more than on objects as actors, and the resulting solution tends to be implemented as series of large-scale transformations, rather than individual object state changes.

Again, remember that C# supports both imperative and functional approaches, so the best design for your application might incorporate elements of both.

See also

- Introduction to Pure Functional Transformations (C#)
- Functional Transformation of XML (C#)
- Refactoring Into Pure Functions (C#)

Functional Transformation of XML (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic discusses the pure functional transformation approach to modifying XML documents, and contrasts it with a procedural approach.

Modifying an XML Document

One of the most common tasks for an XML programmer is transforming XML from one shape to another. The shape of an XML document is the structure of the document, which includes the following:

- The hierarchy expressed by the document.
- The element and attribute names.
- The data types of the elements and attributes.

In general, the most effective approach to transforming XML from one shape to another is that of pure functional transformation. In this approach, the primary programmer task is to create a transformation which is applied to the entire XML document (or to one or more strictly defined nodes). Functional transformation is arguably the easiest to code (after a programmer is familiar with the approach), yields the most maintainable code, and is often more compact than alternative approaches.

XML Functional Transformational Technologies

Microsoft offers two functional transformation technologies for use on XML documents: XSLT and LINQ to XML. XSLT is supported in the System.Xml.Xsl managed namespace and in the native COM implementation of MSXML. Although XSLT is a robust technology for manipulating XML documents, it requires expertise in a specialized domain, namely the XSLT language and its supporting APIs.

LINQ to XML provides the tools necessary to code pure functional transformations in an expressive and powerful way, within C# or Visual Basic code. For example, many of the examples in the LINQ to XML documentation use a pure functional approach. Also, in the Tutorial: Manipulating Content in a WordprocessingML Document (C#) tutorial, we use LINQ to XML in a functional approach to manipulate information in a Microsoft Word document.

For a more complete comparison of LINQ to XML with other Microsoft XML technologies, see LINQ to XML vs. Other XML Technologies.

XSLT is the recommended tool for document-centric transformations when the source document has an irregular structure. However, LINQ to XML can also perform document-centric transforms. For more information, see How to: Use Annotations to Transform LINQ to XML Trees in an XSLT Style (C#).

See also

- Introduction to Pure Functional Transformations (C#)
- Tutorial: Manipulating Content in a WordprocessingML Document (C#)
- LINQ to XML vs. Other XML Technologies

Tutorial: Chaining Queries Together (C#)

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This tutorial illustrates the processing model when you chain queries together. Chaining queries together is a key part of writing functional transformations. It is important to understand exactly how chained queries work.

The queries that process Office Open XML documents use this technique extensively.

In This Section

TOPIC	DESCRIPTION
Deferred Execution and Lazy Evaluation in LINQ to XML (C#)	Describes the concepts of deferred execution and lazy evaluation.
Deferred Execution Example (C#)	Provides an example of deferred execution.
Chaining Queries Example (C#)	Shows how deferred execution works when chaining queries together.
Intermediate Materialization (C#)	Identifies and illustrates the semantics of intermediate materialization.
Chaining Standard Query Operators Together (C#)	Describes the lazy semantics of the standard query operators.

See also

- Pure Functional Transformations of XML (C#)

Deferred Execution and Lazy Evaluation in LINQ to XML (C#)

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Query and axis operations are often implemented to use deferred execution. This topic explains the requirements and advantages of deferred execution, and some implementation considerations.

Deferred Execution

Deferred execution means that the evaluation of an expression is delayed until its *realized* value is actually required. Deferred execution can greatly improve performance when you have to manipulate large data collections, especially in programs that contain a series of chained queries or manipulations. In the best case, deferred execution enables only a single iteration through the source collection.

The LINQ technologies make extensive use of deferred execution in both the members of core System.Linq classes and in the extension methods in the various LINQ namespaces, such as System.Xml.Linq.Extensions.

Deferred execution is supported directly in the C# language by the yield keyword (in the form of the `yield-return` statement) when used within an iterator block. Such an iterator must return a collection of type IEnumerator or IEnumerator<T> (or a derived type).

Eager vs. Lazy Evaluation

When you write a method that implements deferred execution, you also have to decide whether to implement the method using lazy evaluation or eager evaluation.

- In *lazy evaluation*, a single element of the source collection is processed during each call to the iterator. This is the typical way in which iterators are implemented.
- In *eager evaluation*, the first call to the iterator will result in the entire collection being processed. A temporary copy of the source collection might also be required. For example, the OrderBy method has to sort the entire collection before it returns the first element.

Lazy evaluation usually yields better performance because it distributes overhead processing evenly throughout the evaluation of the collection and minimizes the use of temporary data. Of course, for some operations, there is no other option than to materialize intermediate results.

Next Steps

The next topic in this tutorial illustrates deferred execution:

- Deferred Execution Example (C#)

See also

- Tutorial: Chaining Queries Together (C#)
- Concepts and Terminology (Functional Transformation) (C#)
- Aggregation Operations (C#)
- yield

Deferred Execution Example (C#)

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This topic shows how deferred execution and lazy evaluation affect the execution of your LINQ to XML queries.

Example

The following example shows the order of execution when using an extension method that uses deferred execution. The example declares an array of three strings. It then iterates through the collection returned by `ConvertCollectionToUpperCase`.

```
public static class LocalExtensions
{
    public static IEnumerable<string>
      ConvertCollectionToUpperCase(this IEnumerable<string> source)
    {
        foreach (string str in source)
        {
            Console.WriteLine("ToUpper: source {0}", str);
            yield return str.ToUpper();
        }
    }
}

class Program
{
    static void Main(string[] args)
    {
        string[] stringArray = { "abc", "def", "ghi" };

        var q = from str in stringArray.ConvertCollectionToUpperCase()
                select str;

        foreach (string str in q)
            Console.WriteLine("Main: str {0}", str);
    }
}
```

This example produces the following output:

```
ToUpper: source abc
Main: str ABC
ToUpper: source def
Main: str DEF
ToUpper: source ghi
Main: str GHI
```

Notice that when iterating through the collection returned by `ConvertCollectionToUpperCase`, each item is retrieved from the source string array and converted to uppercase before the next item is retrieved from the source string array.

You can see that the entire array of strings is not converted to uppercase before each item in the returned collection is processed in the `foreach` loop in `Main`.

The next topic in this tutorial illustrates chaining queries together:

- Chaining Queries Example (C#)

See also

- Tutorial: Chaining Queries Together (C#)

Chaining Queries Example (C#)

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This example builds on the previous example and shows what happens when you chain together two queries that both use deferred execution and lazy evaluation.

Example

In this example, another extension method is introduced, `AppendString`, which appends a specified string onto every string in the source collection, and then yields the new strings.

```
public static class LocalExtensions
{
    public static IEnumerable<string>
      ConvertCollectionToUpperCase(this IEnumerable<string> source)
    {
        foreach (string str in source)
        {
            Console.WriteLine("ToUpper: source >{0}<", str);
            yield return str.ToUpper();
        }
    }

    public static IEnumerable<string>
      AppendString(this IEnumerable<string> source, string stringToAppend)
    {
        foreach (string str in source)
        {
            Console.WriteLine("AppendString: source >{0}<", str);
            yield return str + stringToAppend;
        }
    }
}

class Program
{
    static void Main(string[] args)
    {
        string[] stringArray = { "abc", "def", "ghi" };

        IEnumerable<string> q1 =
            from s in stringArray.ConvertCollectionToUpperCase()
            select s;

        IEnumerable<string> q2 =
            from s in q1.AppendString("!!!")
            select s;

        foreach (string str in q2)
        {
            Console.WriteLine("Main: str >{0}<", str);
            Console.WriteLine();
        }
    }
}
```

This example produces the following output:

```
ToUpper: source >abc<
AppendString: source >ABC<
Main: str >ABC!!!<

ToUpper: source >def<
AppendString: source >DEF<
Main: str >DEF!!!<

ToUpper: source >ghi<
AppendString: source >GHI<
Main: str >GHI!!!<
```

In this example, you can see that each extension method operates one at a time for each item in the source collection.

What should be clear from this example is that even though we have chained together queries that yield collections, no intermediate collections are materialized. Instead, each item is passed from one lazy method to the next. This results in a much smaller memory footprint than an approach that would first take one array of strings, then create a second array of strings that have been converted to uppercase, and finally create a third array of strings where each string has the exclamation points appended to it.

The next topic in this tutorial illustrates intermediate materialization:

- Intermediate Materialization (C#)

See also

- Tutorial: Chaining Queries Together (C#)

Intermediate Materialization (C#)

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If you are not careful, in some situations you can drastically alter the memory and performance profile of your application by causing premature materialization of collections in your queries. Some standard query operators cause materialization of their source collection before yielding a single element. For example, Enumerable.OrderBy first iterates through its entire source collection, then sorts all items, and then finally yields the first item. This means that it is expensive to get the first item of an ordered collection; each item thereafter is not expensive. This makes sense: It would be impossible for that query operator to do otherwise.

Example

This example alters the previous example. The `AppendString` method calls ToList before iterating through the source. This causes materialization.

```
public static class LocalExtensions
{
    public static IEnumerable<string>
      ConvertCollectionToUpperCase(this IEnumerable<string> source)
    {
        foreach (string str in source)
        {
            Console.WriteLine("ToUpper: source >{0}<", str);
            yield return str.ToUpper();
        }
    }

    public static IEnumerable<string>
      AppendString(this IEnumerable<string> source, string stringToAppend)
    {
        // the following statement materializes the source collection in a List<T>
        // before iterating through it
        foreach (string str in source.ToList())
        {
            Console.WriteLine("AppendString: source >{0}<", str);
            yield return str + stringToAppend;
        }
    }
}

class Program
{
    static void Main(string[] args)
    {
        string[] stringArray = { "abc", "def", "ghi" };

        IEnumerable<string> q1 =
            from s in stringArray.ConvertCollectionToUpperCase()
            select s;

        IEnumerable<string> q2 =
            from s in q1.AppendString("!!!")
            select s;

        foreach (string str in q2)
        {
            Console.WriteLine("Main: str >{0}<", str);
            Console.WriteLine();
        }
    }
}
```

This example produces the following output:

```
ToUpper: source >abc<
ToUpper: source >def<
ToUpper: source >ghi<
AppendString: source >ABC<
Main: str >ABC!!!<

AppendString: source >DEF<
Main: str >DEF!!!<

AppendString: source >GHI<
Main: str >GHI!!!<
```

In this example, you can see that the call to ToList causes `AppendString` to enumerate its entire source before yielding the first item. If the source were a large array, this would significantly alter the memory profile of the application.

Standard query operators can also be chained together. The final topic in this tutorial illustrates this.

- Chaining Standard Query Operators Together (C#)

See also

- Tutorial: Chaining Queries Together (C#)

Chaining Standard Query Operators Together (C#)

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This is the final topic in the Tutorial: Chaining Queries Together (C#) tutorial.

The standard query operators can also be chained together. For example, you can interject the Enumerable.Where operator, and it also operates in a lazy fashion. No intermediate results are materialized by it.

Example

In this example, the Where method is called before calling `ConvertCollectionToUpperCase`. The Where method operates in almost exactly the same way as the lazy methods used in previous examples in this tutorial, `ConvertCollectionToUpperCase` and `AppendString`.

One difference is that in this case, the Where method iterates through its source collection, determines that the first item does not pass the predicate, and then gets the next item, which does pass. It then yields the second item.

However, the basic idea is the same: Intermediate collections are not materialized unless they have to be.

When query expressions are used, they are converted to calls to the standard query operators, and the same principles apply.

All of the examples in this section that are querying Office Open XML documents use the same principle. Deferred execution and lazy evaluation are some of the fundamental concepts that you must understand to use LINQ (and LINQ to XML) effectively.

```
public static class LocalExtensions
{
    public static IEnumerable<string>
      ConvertCollectionToUpperCase(this IEnumerable<string> source)
    {
        foreach (string str in source)
        {
            Console.WriteLine("ToUpper: source >{0}<", str);
            yield return str.ToUpper();
        }
    }

    public static IEnumerable<string>
      AppendString(this IEnumerable<string> source, string stringToAppend)
    {
        foreach (string str in source)
        {
            Console.WriteLine("AppendString: source >{0}<", str);
            yield return str + stringToAppend;
        }
    }
}

class Program
{
    static void Main(string[] args)
    {
        string[] stringArray = { "abc", "def", "ghi" };

        IEnumerable<string> q1 =
            from s in stringArray.ConvertCollectionToUpperCase()
            where s.CompareTo("D") >= 0
            select s;

        IEnumerable<string> q2 =
            from s in q1.AppendString("!!!")
            select s;

        foreach (string str in q2)
        {
            Console.WriteLine("Main: str >{0}<", str);
            Console.WriteLine();
        }
    }
}
```

This example produces the following output:

```
ToUpper: source >abc<
ToUpper: source >def<
AppendString: source >DEF<
Main: str >DEF!!!<

ToUpper: source >ghi<
AppendString: source >GHI<
Main: str >GHI!!!<
```

See also

- Tutorial: Chaining Queries Together (C#)

Tutorial: Manipulating Content in a WordprocessingML Document (C#)

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This tutorial shows how to apply the functional transformational approach and LINQ to XML to manipulate XML documents. The C# examples query and manipulate information in Office Open XML WordprocessingML documents that are saved by Microsoft Word.

For more information, see Introduction to WordprocessingML.

In This Section

TOPIC	DESCRIPTION
Shape of WordprocessingML Documents (C#)	Provides a quick explanation of details of a WordprocessingML document.
Creating the Source Office Open XML Document (C#)	Provides step-by-step instructions to create the source document for queries in this tutorial.
Finding the Default Paragraph Style (C#)	Shows a query to find the name of the default style for a document.
Retrieving the Paragraphs and Their Styles (C#)	Shows a query that retrieves a collection of the paragraphs of a document.
Retrieving the Text of the Paragraphs (C#)	Augments the previous query to retrieve the text of each paragraph.
Refactoring Using an Extension Method (C#)	Simplifies the code by refactoring using an extension method.
Refactoring Using a Pure Function (C#)	Further simplifies the code by refactoring using a pure function.
Projecting XML in a Different Shape (C#)	Completes an XML transformation by projecting XML in a different shape than the original document.
Finding Text in Word Documents (C#)	Uses the previous queries to find a specified text string in a document.
Details of Office Open XML WordprocessingML Documents (C#)	Provides some details of Office Open XML WordprocessingML documents.

See also

- Pure Functional Transformations of XML (C#)
- Introduction to Pure Functional Transformations (C#)

Shape of WordprocessingML Documents (C#)

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This topic introduces the XML shape of a WordprocessingML document.

Microsoft Office Formats

The native file format for the 2007 Microsoft Office system is Office Open XML (commonly called Open XML). Open XML is an XML-based format that an Ecma standard and is currently going through the ISO-IEC standards process. The markup language for word processing files within Open XML is called WordprocessingML. This tutorial uses WordprocessingML source files as input for the examples.

If you are using Microsoft Office 2003, you can save documents in the Office Open XML format if you have installed the Microsoft Office Compatibility Pack for Word, Excel, and PowerPoint 2007 File Formats.

The Shape of WordprocessingML Documents

The first thing to understand is the shape of WordprocessingML documents. A WordprocessingML document contains a body element (named `w:body`) that contains the paragraphs of the document. Each paragraph contains one or more text runs (named `w:r`). Each text run contains one or more text pieces (named `w:t`).

The following is a very simple WordprocessingML document:

```xml
<?xml version="1.0" encoding="utf-8" standalone="yes"?>
<w:document
xmlns:ve="http://schemas.openxmlformats.org/markup-compatibility/2006"
xmlns:o="urn:schemas-microsoft-com:office:office"
xmlns:r="http://schemas.openxmlformats.org/officeDocument/2006/relationships"
xmlns:m="http://schemas.openxmlformats.org/officeDocument/2006/math"
xmlns:v="urn:schemas-microsoft-com:vml"
xmlns:wp="http://schemas.openxmlformats.org/drawingml/2006/wordprocessingDrawing"
xmlns:w10="urn:schemas-microsoft-com:office:word"
xmlns:w="http://schemas.openxmlformats.org/wordprocessingml/2006/main"
xmlns:wne="http://schemas.microsoft.com/office/word/2006/wordml">
  <w:body>
    <w:p w:rsidR="00E22EB6"
         w:rsidRDefault="00E22EB6">
      <w:r>
        <w:t>This is a paragraph.</w:t>
      </w:r>
    </w:p>
    <w:p w:rsidR="00E22EB6"
         w:rsidRDefault="00E22EB6">
      <w:r>
        <w:t>This is another paragraph.</w:t>
      </w:r>
    </w:p>
  </w:body>
</w:document>
```

This document contains two paragraphs. They both contain a single text run, and each text run contains a single text piece.

The easiest way to see the contents of a WordprocessingML document in XML form is to create one using Microsoft Word, save it, and then run the following program that prints the XML to the console.

This example uses classes found in the WindowsBase assembly. It uses types in the System.IO.Packaging namespace.

```
const string documentRelationshipType =
  "http://schemas.openxmlformats.org/officeDocument/2006/relationships/officeDocument";
const string wordmlNamespace =
  "http://schemas.openxmlformats.org/wordprocessingml/2006/main";
XNamespace w = wordmlNamespace;

using (Package wdPackage = Package.Open("SampleDoc.docx", FileMode.Open, FileAccess.Read))
{
    PackageRelationship relationship =
        wdPackage
        .GetRelationshipsByType(documentRelationshipType)
        .FirstOrDefault();
    if (relationship != null)
    {
        Uri documentUri =
            PackUriHelper.ResolvePartUri(
                new Uri("/", UriKind.Relative),
                relationship.TargetUri);
        PackagePart documentPart = wdPackage.GetPart(documentUri);

        //  Get the officeDocument part from the package.
        //  Load the XML in the part into an XDocument instance.
        XDocument xdoc =
            XDocument.Load(XmlReader.Create(documentPart.GetStream()));
        Console.WriteLine(xdoc.Root);
    }
}
```

External Resources

Introducing the Office (2007) Open XML File Formats
Overview of WordprocessingML
Anatomy of a WordProcessingML File
Introduction to WordprocessingML
Office 2003: XML Reference Schemas Download page

See also

- Tutorial: Manipulating Content in a WordprocessingML Document (C#)

Creating the Source Office Open XML Document (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows how to create the Office Open XML WordprocessingML document that the other examples in this tutorial use. If you follow these instructions, your output will match the output provided in each example.

However, the examples in this tutorial will work with any valid WordprocessingML document.

To create the document that this tutorial uses, you must either have Microsoft Office 2007 or later installed, or you must have Microsoft Office 2003 with the Microsoft Office Compatibility Pack for Word, Excel, and PowerPoint 2007 File Formats.

Creating the WordprocessingML Document

To create the WordprocessingML document

1. Create a new Microsoft Word document.
2. Paste the following text into the new document:

```
Parsing WordprocessingML with LINQ to XML

The following example prints to the console.

using System;

class Program {
    public static void Main(string[] args) {
        Console.WriteLine("Hello World");
    }
}

This example produces the following output:

Hello World
```

3. Format the first line with the style "Heading 1".
4. Select the lines that contain the C# code. The first line starts with the `using` keyword. The last line is the last closing brace. Format the lines with the courier font. Format them with a new style, and name the new style "Code".
5. Finally, select the entire line that contains the output, and format it with the `Code` style.
6. Save the document, and name it SampleDoc.docx.

NOTE

If you are using Microsoft Word 2003, select **Word 2007 Document** in the **Save as Type** drop-down list.

See also

- Tutorial: Manipulating Content in a WordprocessingML Document (C#)

Finding the Default Paragraph Style (C#)

1/23/2019 • 2 minutes to read • Edit Online

The first task in the Manipulating Information in a WordprocessingML Document tutorial is to find the default style of paragraphs in the document.

Example

Description

The following example opens an Office Open XML WordprocessingML document, finds the document and style parts of the package, and then executes a query that finds the default style name. For information about Office Open XML document packages, and the parts they consist of, see Details of Office Open XML WordprocessingML Documents (C#).

The query finds a node named `w:style` that has an attribute named `w:type` with a value of "paragraph", and also has an attribute named `w:default` with a value of "1". Because there will be only one XML node with these attributes, the query uses the Enumerable.First operator to convert a collection to a singleton. It then gets the value of the attribute with the name `w:styleId`.

This example uses classes from the WindowsBase assembly. It uses types in the System.IO.Packaging namespace.

Code

```
const string fileName = "SampleDoc.docx";

const string documentRelationshipType =
  "http://schemas.openxmlformats.org/officeDocument/2006/relationships/officeDocument";
const string stylesRelationshipType =
  "http://schemas.openxmlformats.org/officeDocument/2006/relationships/styles";
const string wordmlNamespace =
  "http://schemas.openxmlformats.org/wordprocessingml/2006/main";
XNamespace w = wordmlNamespace;

XDocument xDoc = null;
XDocument styleDoc = null;

using (Package wdPackage = Package.Open(fileName, FileMode.Open, FileAccess.Read))
{
    PackageRelationship docPackageRelationship =
      wdPackage.GetRelationshipsByType(documentRelationshipType).FirstOrDefault();
    if (docPackageRelationship != null)
    {
        Uri documentUri = PackUriHelper.ResolvePartUri(new Uri("/", UriKind.Relative),
          docPackageRelationship.TargetUri);
        PackagePart documentPart = wdPackage.GetPart(documentUri);

        //  Load the document XML in the part into an XDocument instance.
        xDoc = XDocument.Load(XmlReader.Create(documentPart.GetStream()));

        //  Find the styles part. There will only be one.
        PackageRelationship styleRelation =
          documentPart.GetRelationshipsByType(stylesRelationshipType).FirstOrDefault();
        if (styleRelation != null)
        {
            Uri styleUri = PackUriHelper.ResolvePartUri(documentUri, styleRelation.TargetUri);
            PackagePart stylePart = wdPackage.GetPart(styleUri);

            //  Load the style XML in the part into an XDocument instance.
            styleDoc = XDocument.Load(XmlReader.Create(stylePart.GetStream()));
        }
    }
}

// The following query finds all the paragraphs that have the default style.
string defaultStyle =
    (string)(
        from style in styleDoc.Root.Elements(w + "style")
        where (string)style.Attribute(w + "type") == "paragraph"&&
              (string)style.Attribute(w + "default") == "1"
              select style
    ).First().Attribute(w + "styleId");

Console.WriteLine("The default style is: {0}", defaultStyle);
```

Comments

This example produces the following output:

```
The default style is: Normal
```

Next Steps

In the next example, you'll create a similar query that finds all the paragraphs in a document and their styles:

- Retrieving the Paragraphs and Their Styles (C#)

See also

- Tutorial: Manipulating Content in a WordprocessingML Document

Retrieving the Paragraphs and Their Styles (C#)

1/23/2019 • 3 minutes to read • Edit Online

In this example, we write a query that retrieves the paragraph nodes from a WordprocessingML document. It also identifies the style of each paragraph.

This query builds on the query in the previous example, Finding the Default Paragraph Style (C#), which retrieves the default style from the list of styles. This information is required so that the query can identify the style of paragraphs that do not have a style explicitly set. Paragraph styles are set through the `w:pPr` element; if a paragraph does not contain this element, it is formatted with the default style.

This topic explains the significance of some pieces of the query, then shows the query as part of a complete, working example.

Example

The source of the query to retrieve all the paragraphs in a document and their styles is as follows:

```
xDoc.Root.Element(w + "body").Descendants(w + "p")
```

This expression is similar to the source of the query in the previous example, Finding the Default Paragraph Style (C#). The main difference is that it uses the Descendants axis instead of the Elements axis. The query uses the Descendants axis because in documents that have sections, the paragraphs will not be the direct children of the body element; rather, the paragraphs will be two levels down in the hierarchy. By using the Descendants axis, the code will work of whether or not the document uses sections.

Example

The query uses a `let` clause to determine the element that contains the style node. If there is no element, then `styleNode` is set to `null`:

```
let styleNode = para.Elements(w + "pPr").Elements(w + "pStyle").FirstOrDefault()
```

The `let` clause first uses the Elements axis to find all elements named `pPr`, then uses the Elements extension method to find all child elements named `pStyle`, and finally uses the FirstOrDefault standard query operator to convert the collection to a singleton. If the collection is empty, `styleNode` is set to `null`. This is a useful idiom to look for the `pStyle` descendant node. Note that if the `pPr` child node does not exist, the code does nor fail by throwing an exception; instead, `styleNode` is set to `null`, which is the desired behavior of this `let` clause.

The query projects a collection of an anonymous type with two members, `StyleName` and `ParagraphNode`.

Example

This example processes a WordprocessingML document, retrieving the paragraph nodes from a WordprocessingML document. It also identifies the style of each paragraph. This example builds on the previous examples in this tutorial. The new query is called out in comments in the code below.

You can find instructions for creating the source document for this example in Creating the Source Office Open XML Document (C#).

This example uses classes found in the WindowsBase assembly. It uses types in the System.IO.Packaging namespace.

```
const string fileName = "SampleDoc.docx";

const string documentRelationshipType =
"http://schemas.openxmlformats.org/officeDocument/2006/relationships/officeDocument";
const string stylesRelationshipType =
"http://schemas.openxmlformats.org/officeDocument/2006/relationships/styles";
const string wordmlNamespace = "http://schemas.openxmlformats.org/wordprocessingml/2006/main";
XNamespace w = wordmlNamespace;

XDocument xDoc = null;
XDocument styleDoc = null;

using (Package wdPackage = Package.Open(fileName, FileMode.Open, FileAccess.Read))
{
    PackageRelationship docPackageRelationship =
wdPackage.GetRelationshipsByType(documentRelationshipType).FirstOrDefault();
    if (docPackageRelationship != null)
    {
        Uri documentUri = PackUriHelper.ResolvePartUri(new Uri("/", UriKind.Relative),
docPackageRelationship.TargetUri);
        PackagePart documentPart = wdPackage.GetPart(documentUri);

        //  Load the document XML in the part into an XDocument instance.
        xDoc = XDocument.Load(XmlReader.Create(documentPart.GetStream()));

        //  Find the styles part. There will only be one.
        PackageRelationship styleRelation =
documentPart.GetRelationshipsByType(stylesRelationshipType).FirstOrDefault();
        if (styleRelation != null)
        {
            Uri styleUri = PackUriHelper.ResolvePartUri(documentUri, styleRelation.TargetUri);
            PackagePart stylePart = wdPackage.GetPart(styleUri);

            //  Load the style XML in the part into an XDocument instance.
            styleDoc = XDocument.Load(XmlReader.Create(stylePart.GetStream()));
        }
    }
}

string defaultStyle =
    (string)(
        from style in styleDoc.Root.Elements(w + "style")
        where (string)style.Attribute(w + "type") == "paragraph"&&
              (string)style.Attribute(w + "default") == "1"
              select style
    ).First().Attribute(w + "styleId");

// Following is the new query that finds all paragraphs in the
// document and their styles.
var paragraphs =
    from para in xDoc
                 .Root
                 .Element(w + "body")
                 .Descendants(w + "p")
    let styleNode = para
                    .Elements(w + "pPr")
                    .Elements(w + "pStyle")
                    .FirstOrDefault()
    select new
    {
        ParagraphNode = para,
        StyleName = styleNode != null ?
            (string)styleNode.Attribute(w + "val") :
            defaultStyle
    };

foreach (var p in paragraphs)
    Console.WriteLine("StyleName:{0}", p.StyleName);
```

This example produces the following output when applied to the document described in Creating the Source Office Open XML Document (C#).

```
StyleName:Heading1
StyleName:Normal
StyleName:Normal
StyleName:Normal
StyleName:Code
StyleName:Code
StyleName:Code
StyleName:Code
StyleName:Code
StyleName:Code
StyleName:Code
StyleName:Normal
StyleName:Normal
StyleName:Normal
StyleName:Code
```

Next Steps

In the next topic, Retrieving the Text of the Paragraphs (C#), you'll create a query to retrieve the text of paragraphs.

See also

- Tutorial: Manipulating Content in a WordprocessingML Document (C#)

Retrieving the Text of the Paragraphs (C#)

1/23/2019 • 3 minutes to read • Edit Online

This example builds on the previous example, Retrieving the Paragraphs and Their Styles (C#). This new example retrieves the text of each paragraph as a string.

To retrieve the text, this example adds an additional query that iterates through the collection of anonymous types and projects a new collection of an anonymous type with the addition of a new member, `Text`. It uses the Aggregate standard query operator to concatenate multiple strings into one string.

This technique (that is, first projecting to a collection of an anonymous type, then using this collection to project to a new collection of an anonymous type) is a common and useful idiom. This query could have been written without projecting to the first anonymous type. However, because of lazy evaluation, doing so does not use much additional processing power. The idiom creates more short lived objects on the heap, but this does not substantially degrade performance.

Of course, it would be possible to write a single query that contains the functionality to retrieve the paragraphs, the style of each paragraph, and the text of each paragraph. However, it often is useful to break up a more complicated query into multiple queries because the resulting code is more modular and easier to maintain. Furthermore, if you need to reuse a portion of the query, it is easier to refactor if the queries are written in this manner.

These queries, which are chained together, use the processing model that is examined in detail in the topic Tutorial: Chaining Queries Together (C#).

Example

This example processes a WordprocessingML document, determining the element node, the style name, and the text of each paragraph. This example builds on the previous examples in this tutorial. The new query is called out in comments in the code below.

For instructions for creating the source document for this example, see Creating the Source Office Open XML Document (C#).

This example uses classes from the WindowsBase assembly. It uses types in the System.IO.Packaging namespace.

```
const string fileName = "SampleDoc.docx";

const string documentRelationshipType =
  "http://schemas.openxmlformats.org/officeDocument/2006/relationships/officeDocument";
const string stylesRelationshipType =
  "http://schemas.openxmlformats.org/officeDocument/2006/relationships/styles";
const string wordmlNamespace =
  "http://schemas.openxmlformats.org/wordprocessingml/2006/main";
XNamespace w = wordmlNamespace;

XDocument xDoc = null;
XDocument styleDoc = null;

using (Package wdPackage = Package.Open(fileName, FileMode.Open, FileAccess.Read))
{
    PackageRelationship docPackageRelationship =
      wdPackage.GetRelationshipsByType(documentRelationshipType).FirstOrDefault();
    if (docPackageRelationship != null)
    {
        Uri documentUri = PackUriHelper.ResolvePartUri(new Uri("/", UriKind.Relative),
          docPackageRelationship.TargetUri);
        PackagePart documentPart = wdPackage.GetPart(documentUri);

        //  Load the document XML in the part into an XDocument instance.
        xDoc = XDocument.Load(XmlReader.Create(documentPart.GetStream()));

        //  Find the styles part. There will only be one.
        PackageRelationship styleRelation =
          documentPart.GetRelationshipsByType(stylesRelationshipType).FirstOrDefault();
        if (styleRelation != null)
        {
            Uri styleUri = PackUriHelper.ResolvePartUri(documentUri, styleRelation.TargetUri);
            PackagePart stylePart = wdPackage.GetPart(styleUri);

            //  Load the style XML in the part into an XDocument instance.
            styleDoc = XDocument.Load(XmlReader.Create(stylePart.GetStream()));
        }
    }
}

string defaultStyle =
    (string)(
        from style in styleDoc.Root.Elements(w + "style")
        where (string)style.Attribute(w + "type") == "paragraph"&&
              (string)style.Attribute(w + "default") == "1"
              select style
    ).First().Attribute(w + "styleId");

// Find all paragraphs in the document.
var paragraphs =
    from para in xDoc
                 .Root
                 .Element(w + "body")
                 .Descendants(w + "p")
    let styleNode = para
                    .Elements(w + "pPr")
                    .Elements(w + "pStyle")
                    .FirstOrDefault()
    select new
    {
        ParagraphNode = para,
        StyleName = styleNode != null ?
            (string)styleNode.Attribute(w + "val") :
            defaultStyle
    };

// Following is the new query that retrieves the text of
// each paragraph.
var paraWithText =
    from para in paragraphs
    select new
    {
        ParagraphNode = para.ParagraphNode,
        StyleName = para.StyleName,
        Text = para
               .ParagraphNode
               .Elements(w + "r")
               .Elements(w + "t")
               .Aggregate(
                   new StringBuilder(),
                   (s, i) => s.Append((string)i),
                   s => s.ToString()
               )
    };

foreach (var p in paraWithText)
    Console.WriteLine("StyleName:{0} >{1}<", p.StyleName, p.Text);
```

This example produces the following output when applied to the document described in Creating the Source

Office Open XML Document (C#).

```
StyleName:Heading1 >Parsing WordprocessingML with LINQ to XML<
StyleName:Normal ><
StyleName:Normal >The following example prints to the console.<
StyleName:Normal ><
StyleName:Code >using System;<
StyleName:Code ><
StyleName:Code >class Program {<
StyleName:Code >    public static void (string[] args) {<
StyleName:Code >        Console.WriteLine("Hello World");<
StyleName:Code >    }<
StyleName:Code >}<
StyleName:Normal ><
StyleName:Normal >This example produces the following output:<
StyleName:Normal ><
StyleName:Code >Hello World<
```

Next Steps

The next example shows how to use an extension method, instead of Aggregate, to concatenate multiple strings into a single string.

- Refactoring Using an Extension Method (C#)

See also

- Tutorial: Manipulating Content in a WordprocessingML Document (C#)
- Deferred Execution and Lazy Evaluation in LINQ to XML (C#)

Refactoring Using an Extension Method (C#)

1/23/2019 • 4 minutes to read • Edit Online

This example builds on the previous example, Retrieving the Text of the Paragraphs (C#), by refactoring the concatenation of strings using a pure function that is implemented as an extension method.

The previous example used the Aggregate standard query operator to concatenate multiple strings into one string. However, it is more convenient to write an extension method to do this, because the resulting query smaller and more simple.

Example

This example processes a WordprocessingML document, retrieving the paragraphs, the style of each paragraph, and the text of each paragraph. This example builds on the previous examples in this tutorial.

The example contains multiple overloads of the `StringConcatenate` method.

You can find instructions for creating the source document for this example in Creating the Source Office Open XML Document (C#).

This example uses classes from the WindowsBase assembly. It uses types in the System.IO.Packaging namespace.

```
public static class LocalExtensions
{
    public static string StringConcatenate(this IEnumerable<string> source)
    {
        StringBuilder sb = new StringBuilder();
        foreach (string s in source)
            sb.Append(s);
        return sb.ToString();
    }

    public static string StringConcatenate<T>(this IEnumerable<T> source,
        Func<T, string> func)
    {
        StringBuilder sb = new StringBuilder();
        foreach (T item in source)
            sb.Append(func(item));
        return sb.ToString();
    }

    public static string StringConcatenate(this IEnumerable<string> source, string separator)
    {
        StringBuilder sb = new StringBuilder();
        foreach (string s in source)
            sb.Append(s).Append(separator);
        return sb.ToString();
    }

    public static string StringConcatenate<T>(this IEnumerable<T> source,
        Func<T, string> func, string separator)
    {
        StringBuilder sb = new StringBuilder();
        foreach (T item in source)
            sb.Append(func(item)).Append(separator);
        return sb.ToString();
    }
}
```

Example

There are four overloads of the `StringConcatenate` method. One overload simply takes a collection of strings and returns a single string. Another overload can take a collection of any type, and a delegate that projects from a singleton of the collection to a string. There are two more overloads that allow you to specify a separator string.

The following code uses all four overloads.

```
string[] numbers = { "one", "two", "three" };

Console.WriteLine("{0}", numbers.StringConcatenate());
Console.WriteLine("{0}", numbers.StringConcatenate(":"));

int[] intNumbers = { 1, 2, 3 };
Console.WriteLine("{0}", intNumbers.StringConcatenate(i => i.ToString()));
Console.WriteLine("{0}", intNumbers.StringConcatenate(i => i.ToString(), ":"));
```

This example produces the following output:

```
onetwothree
one:two:three:
123
1:2:3:
```

Example

Now, the example can be modified to take advantage of the new extension method:

```
public static class LocalExtensions
{
    public static string StringConcatenate(this IEnumerable<string> source)
    {
        StringBuilder sb = new StringBuilder();
        foreach (string s in source)
            sb.Append(s);
        return sb.ToString();
    }

    public static string StringConcatenate<T>(this IEnumerable<T> source,
        Func<T, string> func)
    {
        StringBuilder sb = new StringBuilder();
        foreach (T item in source)
            sb.Append(func(item));
        return sb.ToString();
    }

    public static string StringConcatenate(this IEnumerable<string> source, string separator)
    {
        StringBuilder sb = new StringBuilder();
        foreach (string s in source)
            sb.Append(s).Append(separator);
        return sb.ToString();
    }

    public static string StringConcatenate<T>(this IEnumerable<T> source,
        Func<T, string> func, string separator)
    {
        StringBuilder sb = new StringBuilder();
        foreach (T item in source)
            sb.Append(func(item)).Append(separator);
        return sb.ToString();
    }
}

class Program
{
    static void Main(string[] args)
    {
        const string fileName = "SampleDoc.docx";

        const string documentRelationshipType =
          "http://schemas.openxmlformats.org/officeDocument/2006/relationships/officeDocument";
        const string stylesRelationshipType =
          "http://schemas.openxmlformats.org/officeDocument/2006/relationships/styles";
        const string wordmlNamespace =
          "http://schemas.openxmlformats.org/wordprocessingml/2006/main";
        XNamespace w = wordmlNamespace;

        XDocument xDoc = null;
        XDocument styleDoc = null;

        using (Package wdPackage = Package.Open(fileName, FileMode.Open, FileAccess.Read))
        {
            PackageRelationship docPackageRelationship =
              wdPackage.GetRelationshipsByType(documentRelationshipType).FirstOrDefault();
            if (docPackageRelationship != null)
            {
                Uri documentUri = PackUriHelper.ResolvePartUri(new Uri("/", UriKind.Relative),
                  docPackageRelationship.TargetUri);
                PackagePart documentPart = wdPackage.GetPart(documentUri);

                //  Load the document XML in the part into an XDocument instance.
                xDoc = XDocument.Load(XmlReader.Create(documentPart.GetStream()));

                //  Find the styles part. There will only be one.
                PackageRelationship styleRelation =
                  documentPart.GetRelationshipsByType(stylesRelationshipType).FirstOrDefault();
                if (styleRelation != null)
                {
                    Uri styleUri =
                      PackUriHelper.ResolvePartUri(documentUri, styleRelation.TargetUri);
                    PackagePart stylePart = wdPackage.GetPart(styleUri);

                    //  Load the style XML in the part into an XDocument instance.
                    styleDoc = XDocument.Load(XmlReader.Create(stylePart.GetStream()));
                }
            }
        }

        string defaultStyle =
            (string)(
                from style in styleDoc.Root.Elements(w + "style")
                where (string)style.Attribute(w + "type") == "paragraph" &&
                      (string)style.Attribute(w + "default") == "1"
                select style
            ).First().Attribute(w + "styleId");

        // Find all paragraphs in the document.
        var paragraphs =
            from para in xDoc
                         .Root
                         .Element(w + "body")
                         .Descendants(w + "p")
            let styleNode = para
                            .Elements(w + "pPr")
                            .Elements(w + "pStyle")
                            .FirstOrDefault()
            select new
            {
                ParagraphNode = para,
                StyleName = styleNode != null ?
                    (string)styleNode.Attribute(w + "val") :
                    defaultStyle
            };

        // Retrieve the text of each paragraph.
        var paraWithText =
            from para in paragraphs
            select new
            {
                ParagraphNode = para.ParagraphNode,
                StyleName = para.StyleName,
                Text = para
                       .ParagraphNode
                       .Elements(w + "r")
                       .Elements(w + "t")
                       .StringConcatenate(e => (string)e)
            };

        foreach (var p in paraWithText)
            Console.WriteLine("StyleName:{0} >{1}<", p.StyleName, p.Text);
    }
}
```

This example produces the following output when applied to the document described in Creating the Source Office Open XML Document (C#).

```
StyleName:Heading1 >Parsing WordprocessingML with LINQ to XML<
StyleName:Normal ><
StyleName:Normal >The following example prints to the console.<
StyleName:Normal ><
StyleName:Code >using System;<
StyleName:Code ><
StyleName:Code >class Program {<
StyleName:Code >    public static void (string[] args) {<
StyleName:Code >        Console.WriteLine("Hello World");<
StyleName:Code >    }<
StyleName:Code >}<
StyleName:Normal ><
StyleName:Normal >This example produces the following output:<
StyleName:Normal ><
StyleName:Code >Hello World<
```

Note that this refactoring is a variant of refactoring into a pure function. The next topic will introduce the idea of factoring into pure functions in more detail.

Next Steps

The next example shows how to refactor this code in another way, by using pure functions:

- Refactoring Using a Pure Function (Visual Basic)

See also

- Tutorial: Manipulating Content in a WordprocessingML Document (C#)
- Refactoring Into Pure Functions (C#)

Refactoring Using a Pure Function (C#)

1/23/2019 • 3 minutes to read • Edit Online

The following example refactors the previous example, Refactoring Using an Extension Method (C#), to use a pure function In this example, the code to find the text of a paragraph is moved to the pure static method `ParagraphText`
.

Example

This example processes a WordprocessingML document, retrieving the paragraph nodes from a WordprocessingML document. It also identifies the style of each paragraph. This example builds on the previous examples in this tutorial. The refactored code is called out in comments in the code below.

For instructions for creating the source document for this example, see Creating the Source Office Open XML Document (C#).

This example uses classes from the WindowsBase assembly. It uses types in the System.IO.Packaging namespace.

```
public static class LocalExtensions
{
    public static string StringConcatenate(this IEnumerable<string> source)
    {
        StringBuilder sb = new StringBuilder();
        foreach (string s in source)
            sb.Append(s);
        return sb.ToString();
    }

    public static string StringConcatenate<T>(this IEnumerable<T> source,
        Func<T, string> func)
    {
        StringBuilder sb = new StringBuilder();
        foreach (T item in source)
            sb.Append(func(item));
        return sb.ToString();
    }

    public static string StringConcatenate(this IEnumerable<string> source, string separator)
    {
        StringBuilder sb = new StringBuilder();
        foreach (string s in source)
            sb.Append(s).Append(separator);
        return sb.ToString();
    }

    public static string StringConcatenate<T>(this IEnumerable<T> source,
        Func<T, string> func, string separator)
    {
        StringBuilder sb = new StringBuilder();
        foreach (T item in source)
            sb.Append(func(item)).Append(separator);
        return sb.ToString();
    }
}

class Program
{
    // This is a new method that assembles the paragraph text.
    public static string ParagraphText(XElement e)
    {
        XNamespace w = e.Name.Namespace;
        return e
               .Elements(w + "r")
               .Elements(w + "t")
               .StringConcatenate(element => (string)element);
    }

    static void Main(string[] args)
    {
        const string fileName = "SampleDoc.docx";

        const string documentRelationshipType =
          "http://schemas.openxmlformats.org/officeDocument/2006/relationships/officeDocument";
        const string stylesRelationshipType =
          "http://schemas.openxmlformats.org/officeDocument/2006/relationships/styles";
        const string wordmlNamespace =
          "http://schemas.openxmlformats.org/wordprocessingml/2006/main";
        XNamespace w = wordmlNamespace;

        XDocument xDoc = null;
        XDocument styleDoc = null;

        using (Package wdPackage = Package.Open(fileName, FileMode.Open, FileAccess.Read))
        {
            PackageRelationship docPackageRelationship =
              wdPackage.GetRelationshipsByType(documentRelationshipType).FirstOrDefault();
            if (docPackageRelationship != null)
            {
                Uri documentUri = PackUriHelper.ResolvePartUri(new Uri("/", UriKind.Relative),
                  docPackageRelationship.TargetUri);
                PackagePart documentPart = wdPackage.GetPart(documentUri);

                //  Load the document XML in the part into an XDocument instance.
                xDoc = XDocument.Load(XmlReader.Create(documentPart.GetStream()));

                //  Find the styles part. There will only be one.
                PackageRelationship styleRelation =
                  documentPart.GetRelationshipsByType(stylesRelationshipType).FirstOrDefault();
                if (styleRelation != null)
                {
                    Uri styleUri = PackUriHelper.ResolvePartUri(documentUri,
                      styleRelation.TargetUri);
                    PackagePart stylePart = wdPackage.GetPart(styleUri);

                    //  Load the style XML in the part into an XDocument instance.
                    styleDoc = XDocument.Load(XmlReader.Create(stylePart.GetStream()));
                }
            }
        }

        string defaultStyle =
            (string)(
                from style in styleDoc.Root.Elements(w + "style")
                where (string)style.Attribute(w + "type") == "paragraph" &&
                      (string)style.Attribute(w + "default") == "1"
                select style
            ).First().Attribute(w + "styleId");

        // Find all paragraphs in the document.
        var paragraphs =
            from para in xDoc
                         .Root
                         .Element(w + "body")
                         .Descendants(w + "p")
            let styleNode = para
                            .Elements(w + "pPr")
                            .Elements(w + "pStyle")
                            .FirstOrDefault()
            select new
            {
                ParagraphNode = para,
                StyleName = styleNode != null ?
                    (string)styleNode.Attribute(w + "val") :
                    defaultStyle
            };

        // Retrieve the text of each paragraph.
        var paraWithText =
            from para in paragraphs
            select new
            {
                ParagraphNode = para.ParagraphNode,
                StyleName = para.StyleName,
                Text = ParagraphText(para.ParagraphNode)
            };

        foreach (var p in paraWithText)
            Console.WriteLine("StyleName:{0} >{1}<", p.StyleName, p.Text);
    }
}
```

This example produces the same output as before the refactoring:

```
StyleName:Heading1 >Parsing WordprocessingML with LINQ to XML<
StyleName:Normal ><
StyleName:Normal >The following example prints to the console.<
StyleName:Normal ><
StyleName:Code >using System;<
StyleName:Code ><
StyleName:Code >class Program {<
StyleName:Code >    public static void (string[] args) {<
StyleName:Code >        Console.WriteLine("Hello World");<
StyleName:Code >    }<
StyleName:Code >}<
StyleName:Normal ><
StyleName:Normal >This example produces the following output:<
StyleName:Normal ><
StyleName:Code >Hello World<
```

Next Steps

The next example shows how to project XML into a different shape:

- Projecting XML in a Different Shape (C#)

See also

- Tutorial: Manipulating Content in a WordprocessingML Document (C#)
- Refactoring Using an Extension Method (C#)
- Refactoring Into Pure Functions (C#)

Projecting XML in a Different Shape (C#)

1/23/2019 • 3 minutes to read • Edit Online

This topic shows an example of projecting XML that is in a different shape than the source XML.

Many typical XML transformations consist of chained queries, as in this example. It is common to start with some form of XML, project intermediate results as collections of anonymous types or named types, and then finally to project the results back into XML that is in an entirely different shape than the source XML.

Example

This example processes a WordprocessingML document, retrieving the paragraph nodes from a WordprocessingML document. It also identifies the style and text of each paragraph. Finally, the example projects XML with a different shape. This example builds on the previous examples in this tutorial. The new statement that does the projection is called out in comments in the code below.

For instructions for creating the source document for this example, see Creating the Source Office Open XML Document (C#).

This example uses classes from the WindowsBase assembly. It uses types in the System.IO.Packaging namespace.

```
public static class LocalExtensions
{
    public static string StringConcatenate(this IEnumerable<string> source)
    {
        StringBuilder sb = new StringBuilder();
        foreach (string s in source)
            sb.Append(s);
        return sb.ToString();
    }

    public static string StringConcatenate<T>(this IEnumerable<T> source,
        Func<T, string> func)
    {
        StringBuilder sb = new StringBuilder();
        foreach (T item in source)
            sb.Append(func(item));
        return sb.ToString();
    }

    public static string StringConcatenate(this IEnumerable<string> source, string separator)
    {
        StringBuilder sb = new StringBuilder();
        foreach (string s in source)
            sb.Append(s).Append(separator);
        return sb.ToString();
    }

    public static string StringConcatenate<T>(this IEnumerable<T> source,
        Func<T, string> func, string separator)
    {
        StringBuilder sb = new StringBuilder();
        foreach (T item in source)
            sb.Append(func(item)).Append(separator);
        return sb.ToString();
    }
}

class Program
```

```
{
    public static string ParagraphText(XElement e)
    {
        XNamespace w = e.Name.Namespace;
        return e
               .Elements(w + "r")
               .Elements(w + "t")
               .StringConcatenate(element => (string)element);
    }

    static void Main(string[] args)
    {
        const string fileName = "SampleDoc.docx";

        const string documentRelationshipType =
          "http://schemas.openxmlformats.org/officeDocument/2006/relationships/officeDocument";
        const string stylesRelationshipType =
          "http://schemas.openxmlformats.org/officeDocument/2006/relationships/styles";
        const string wordmlNamespace =
          "http://schemas.openxmlformats.org/wordprocessingml/2006/main";
        XNamespace w = wordmlNamespace;

        XDocument xDoc = null;
        XDocument styleDoc = null;

        using (Package wdPackage = Package.Open(fileName, FileMode.Open, FileAccess.Read))
        {
            PackageRelationship docPackageRelationship =
              wdPackage.GetRelationshipsByType(documentRelationshipType).FirstOrDefault();
            if (docPackageRelationship != null)
            {
                Uri documentUri = PackUriHelper.ResolvePartUri(new Uri("/", UriKind.Relative),
                  docPackageRelationship.TargetUri);
                PackagePart documentPart = wdPackage.GetPart(documentUri);

                //  Load the document XML in the part into an XDocument instance.
                xDoc = XDocument.Load(XmlReader.Create(documentPart.GetStream()));

                //  Find the styles part. There will only be one.
                PackageRelationship styleRelation =
                  documentPart.GetRelationshipsByType(stylesRelationshipType).FirstOrDefault();
                if (styleRelation != null)
                {
                    Uri styleUri =
                      PackUriHelper.ResolvePartUri(documentUri, styleRelation.TargetUri);
                    PackagePart stylePart = wdPackage.GetPart(styleUri);

                    //  Load the style XML in the part into an XDocument instance.
                    styleDoc = XDocument.Load(XmlReader.Create(stylePart.GetStream()));
                }
            }
        }

        string defaultStyle =
            (string)(
                from style in styleDoc.Root.Elements(w + "style")
                where (string)style.Attribute(w + "type") == "paragraph" &&
                      (string)style.Attribute(w + "default") == "1"
                select style
            ).First().Attribute(w + "styleId");

        // Find all paragraphs in the document.
        var paragraphs =
            from para in xDoc
                         .Root
                         .Element(w + "body")
                         .Descendants(w + "p")
            let styleNode = para
                            .Elements(w + "pPr")
```

```
                              .Elements(w + "pStyle")
                              .FirstOrDefault()
               select new
               {
                   ParagraphNode = para,
                   StyleName = styleNode != null ?
                       (string)styleNode.Attribute(w + "val") :
                       defaultStyle
               };

           // Retrieve the text of each paragraph.
           var paraWithText =
               from para in paragraphs
               select new
               {
                   ParagraphNode = para.ParagraphNode,
                   StyleName = para.StyleName,
                   Text = ParagraphText(para.ParagraphNode)
               };

           // The following is the new code that projects XML in a new shape.
           XElement root = new XElement("Root",
               from p in paraWithText
               select new XElement("Paragraph",
                   new XElement("StyleName", p.StyleName),
                   new XElement("Text", p.Text)
               )
           );

           Console.WriteLine(root);
       }
   }
```

This example produces the following output:

```xml
<Root>
  <Paragraph>
    <StyleName>Heading1</StyleName>
    <Text>Parsing WordprocessingML with LINQ to XML</Text>
  </Paragraph>
  <Paragraph>
    <StyleName>Normal</StyleName>
    <Text></Text>
  </Paragraph>
  <Paragraph>
    <StyleName>Normal</StyleName>
    <Text>The following example prints to the console.</Text>
  </Paragraph>
  <Paragraph>
    <StyleName>Normal</StyleName>
    <Text></Text>
  </Paragraph>
  <Paragraph>
    <StyleName>Code</StyleName>
    <Text>using System;</Text>
  </Paragraph>
  <Paragraph>
    <StyleName>Code</StyleName>
    <Text></Text>
  </Paragraph>
  <Paragraph>
    <StyleName>Code</StyleName>
    <Text>class Program {</Text>
  </Paragraph>
  <Paragraph>
    <StyleName>Code</StyleName>
    <Text>    public static void (string[] args) {</Text>
  </Paragraph>
  <Paragraph>
    <StyleName>Code</StyleName>
    <Text>        Console.WriteLine("Hello World");</Text>
  </Paragraph>
  <Paragraph>
    <StyleName>Code</StyleName>
    <Text>    }</Text>
  </Paragraph>
  <Paragraph>
    <StyleName>Code</StyleName>
    <Text>}</Text>
  </Paragraph>
  <Paragraph>
    <StyleName>Normal</StyleName>
    <Text></Text>
  </Paragraph>
  <Paragraph>
    <StyleName>Normal</StyleName>
    <Text>This example produces the following output:</Text>
  </Paragraph>
  <Paragraph>
    <StyleName>Normal</StyleName>
    <Text></Text>
  </Paragraph>
  <Paragraph>
    <StyleName>Code</StyleName>
    <Text>Hello World</Text>
  </Paragraph>
</Root>
```

Next Steps

In the next example, you'll query to find all the text in a Word document:

- Finding Text in Word Documents (C#)

See also

- Tutorial: Manipulating Content in a WordprocessingML Document (C#)

Finding Text in Word Documents (C#)

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This topic extends the previous queries to do something useful: find all occurrences of a string in the document.

Example

This example processes a WordprocessingML document, to find all the occurrences of a specific piece of text in the document. To do this, we use a query that finds the string "Hello". This example builds on the previous examples in this tutorial. The new query is called out in comments in the code below.

For instructions for creating the source document for this example, see Creating the Source Office Open XML Document (C#).

This example uses classes found in the WindowsBase assembly. It uses types in the System.IO.Packaging namespace.

```
public static class LocalExtensions
{
    public static string StringConcatenate(this IEnumerable<string> source)
    {
        StringBuilder sb = new StringBuilder();
        foreach (string s in source)
            sb.Append(s);
        return sb.ToString();
    }

    public static string StringConcatenate<T>(this IEnumerable<T> source,
        Func<T, string> func)
    {
        StringBuilder sb = new StringBuilder();
        foreach (T item in source)
            sb.Append(func(item));
        return sb.ToString();
    }

    public static string StringConcatenate(this IEnumerable<string> source, string separator)
    {
        StringBuilder sb = new StringBuilder();
        foreach (string s in source)
            sb.Append(s).Append(separator);
        return sb.ToString();
    }

    public static string StringConcatenate<T>(this IEnumerable<T> source,
        Func<T, string> func, string separator)
    {
        StringBuilder sb = new StringBuilder();
        foreach (T item in source)
            sb.Append(func(item)).Append(separator);
        return sb.ToString();
    }
}

class Program
{
    public static string ParagraphText(XElement e)
    {
        XNamespace w = e.Name.Namespace;
        return e
```

```
                .Elements(w + "r")
                .Elements(w + "t")
                .StringConcatenate(element => (string)element);
    }

    static void Main(string[] args)
    {
        const string fileName = "SampleDoc.docx";

        const string documentRelationshipType =
          "http://schemas.openxmlformats.org/officeDocument/2006/relationships/officeDocument";
        const string stylesRelationshipType =
          "http://schemas.openxmlformats.org/officeDocument/2006/relationships/styles";
        const string wordmlNamespace =
          "http://schemas.openxmlformats.org/wordprocessingml/2006/main";
        XNamespace w = wordmlNamespace;

        XDocument xDoc = null;
        XDocument styleDoc = null;

        using (Package wdPackage = Package.Open(fileName, FileMode.Open, FileAccess.Read))
        {
            PackageRelationship docPackageRelationship =
              wdPackage.GetRelationshipsByType(documentRelationshipType).FirstOrDefault();
            if (docPackageRelationship != null)
            {
                Uri documentUri = PackUriHelper.ResolvePartUri(new Uri("/", UriKind.Relative),
                  docPackageRelationship.TargetUri);
                PackagePart documentPart = wdPackage.GetPart(documentUri);

                //  Load the document XML in the part into an XDocument instance.
                xDoc = XDocument.Load(XmlReader.Create(documentPart.GetStream()));

                //  Find the styles part. There will only be one.
                PackageRelationship styleRelation =
                  documentPart.GetRelationshipsByType(stylesRelationshipType).FirstOrDefault();
                if (styleRelation != null)
                {
                    Uri styleUri =
                      PackUriHelper.ResolvePartUri(documentUri, styleRelation.TargetUri);
                    PackagePart stylePart = wdPackage.GetPart(styleUri);

                    //  Load the style XML in the part into an XDocument instance.
                    styleDoc = XDocument.Load(XmlReader.Create(stylePart.GetStream()));
                }
            }
        }

        string defaultStyle =
            (string)(
                from style in styleDoc.Root.Elements(w + "style")
                where (string)style.Attribute(w + "type") == "paragraph" &&
                      (string)style.Attribute(w + "default") == "1"
                select style
            ).First().Attribute(w + "styleId");

        // Find all paragraphs in the document.
        var paragraphs =
            from para in xDoc
                         .Root
                         .Element(w + "body")
                         .Descendants(w + "p")
            let styleNode = para
                            .Elements(w + "pPr")
                            .Elements(w + "pStyle")
                            .FirstOrDefault()
            select new
            {
                ParagraphNode = para,
                ParagraphNode = para,
                StyleName = styleNode != null ?
                    (string)styleNode.Attribute(w + "val") :
                    defaultStyle
            };

        // Retrieve the text of each paragraph.
        var paraWithText =
            from para in paragraphs
            select new
            {
                ParagraphNode = para.ParagraphNode,
                StyleName = para.StyleName,
                Text = ParagraphText(para.ParagraphNode)
            };

        // Following is the new query that retrieves all paragraphs
        // that have specific text in them.
        var helloParagraphs =
            from para in paraWithText
            where para.Text.Contains("Hello")
            select new
            {
                ParagraphNode = para.ParagraphNode,
                StyleName = para.StyleName,
                Text = para.Text
            };

        foreach (var p in helloParagraphs)
            Console.WriteLine("StyleName:{0} >{1}<", p.StyleName, p.Text);
    }
}
```

This example produces the following output:

```
StyleName:Code >        Console.WriteLine("Hello World");<
StyleName:Code >Hello World<
```

You can, of course, modify the search so that it searches for lines with a specific style. The following query finds all blank lines that have the Code style:

```
public static class LocalExtensions
{
    public static string StringConcatenate(this IEnumerable<string> source)
    {
        StringBuilder sb = new StringBuilder();
        foreach (string s in source)
            sb.Append(s);
        return sb.ToString();
    }

    public static string StringConcatenate<T>(this IEnumerable<T> source,
        Func<T, string> func)
    {
        StringBuilder sb = new StringBuilder();
        foreach (T item in source)
            sb.Append(func(item));
        return sb.ToString();
    }

    public static string StringConcatenate(this IEnumerable<string> source, string separator)
    {
        StringBuilder sb = new StringBuilder();
        foreach (string s in source)
            sb.Append(s).Append(separator);
        return sb.ToString();
        return sb.ToString();
    }

    public static string StringConcatenate<T>(this IEnumerable<T> source,
        Func<T, string> func, string separator)
    {
        StringBuilder sb = new StringBuilder();
        foreach (T item in source)
            sb.Append(func(item)).Append(separator);
        return sb.ToString();
    }
}

class Program
{
    public static string ParagraphText(XElement e)
    {
        XNamespace w = e.Name.Namespace;
        return e
               .Elements(w + "r")
               .Elements(w + "t")
               .StringConcatenate(element => (string)element);
    }

    static void Main(string[] args)
    {
        const string fileName = "SampleDoc.docx";

        const string documentRelationshipType =
"http://schemas.openxmlformats.org/officeDocument/2006/relationships/officeDocument";
        const string stylesRelationshipType =
"http://schemas.openxmlformats.org/officeDocument/2006/relationships/styles";
        const string wordmlNamespace = "http://schemas.openxmlformats.org/wordprocessingml/2006/main";
        XNamespace w = wordmlNamespace;

        XDocument xDoc = null;
        XDocument styleDoc = null;

        using (Package wdPackage = Package.Open(fileName, FileMode.Open, FileAccess.Read))
        {
            PackageRelationship docPackageRelationship =
wdPackage.GetRelationshipsByType(documentRelationshipType).FirstOrDefault();
            if (docPackageRelationship != null)
            {
                Uri documentUri = PackUriHelper.ResolvePartUri(new Uri("/", UriKind.Relative),
docPackageRelationship.TargetUri);
                PackagePart documentPart = wdPackage.GetPart(documentUri);

                //  Load the document XML in the part into an XDocument instance.
                xDoc = XDocument.Load(XmlReader.Create(documentPart.GetStream()));

                //  Find the styles part. There will only be one.
                PackageRelationship styleRelation =
documentPart.GetRelationshipsByType(stylesRelationshipType).FirstOrDefault();
                if (styleRelation != null)
                {
                    Uri styleUri = PackUriHelper.ResolvePartUri(documentUri, styleRelation.TargetUri);
                    PackagePart stylePart = wdPackage.GetPart(styleUri);

                    //  Load the style XML in the part into an XDocument instance.
                    styleDoc = XDocument.Load(XmlReader.Create(stylePart.GetStream()));
                }
            }
        }

        string defaultStyle =
            (string)(
                from style in styleDoc.Root.Elements(w + "style")
                where (string)style.Attribute(w + "type") == "paragraph" &&
                      (string)style.Attribute(w + "default") == "1"
                      (string)style.Attribute(w + "default") == "1"
                select style
            ).First().Attribute(w + "styleId");

        // Find all paragraphs in the document.
        var paragraphs =
            from para in xDoc
                         .Root
                         .Element(w + "body")
                         .Descendants(w + "p")
            let styleNode = para
                            .Elements(w + "pPr")
                            .Elements(w + "pStyle")
                            .FirstOrDefault()
            select new
            {
                ParagraphNode = para,
                StyleName = styleNode != null ?
                    (string)styleNode.Attribute(w + "val") :
                    defaultStyle
            };

        // Retrieve the text of each paragraph.
        var paraWithText =
            from para in paragraphs
            select new
            {
                ParagraphNode = para.ParagraphNode,
                StyleName = para.StyleName,
                Text = ParagraphText(para.ParagraphNode)
            };

        // Retrieve all paragraphs that have no text and are styled Code.
        var blankCodeParagraphs =
            from para in paraWithText
            where para.Text == "" && para.StyleName == "Code"
            select new
            {
                ParagraphNode = para.ParagraphNode,
                StyleName = para.StyleName,
                Text = para.Text
            };

        foreach (var p in blankCodeParagraphs)
            Console.WriteLine("StyleName:{0} >{1}<", p.StyleName, p.Text);
    }
}
```

This example produces the following output:

```
StyleName:Code ><
```

Of course, this example could be enhanced in a number of ways. For example, we could use regular expressions to search for text, we could iterate through all the Word files in a particular directory, and so on.

Note that this example performs approximately as well as if it were written as a single query. Because each query is implemented in a lazy, deferred fashion, each query does not yield its results until the query is iterated. For more information about execution and lazy evaluation, see Deferred Execution and Lazy Evaluation in LINQ to XML (C#).

Next Steps

The next section provides more information about WordprocessingML documents:

- Details of Office Open XML WordprocessingML Documents (C#)

See also

- Tutorial: Manipulating Content in a WordprocessingML Document (C#)
- Refactoring Using a Pure Function (C#)
- Deferred Execution and Lazy Evaluation in LINQ to XML (C#)

Details of Office Open XML WordprocessingML Documents (C#)

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This section provides information about the details of Office Open XML WordprocessingML documents. It shows examples of the document and style parts of an Open XML document.

In This Section

TOPIC	DESCRIPTION
WordprocessingML Document with Styles	Shows the document part of an Office Open XML WordprocessingML document.
Style Part of a WordprocessingML Document	Shows the style part of an Office Open XML WordprocessingML document.
Example that Outputs Office Open XML Document Parts (C#)	Provides an example that opens an Office Open XML WordprocessingML document, and outputs the parts to the console.

See also

- Tutorial: Manipulating Content in a WordprocessingML Document (C#)

WordprocessingML Document with Styles

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More complicated WordprocessingML documents have paragraphs that are formatted with styles.

A few notes about the makeup of WordprocessingML documents are helpful. WordprocessingML documents are stored in packages. Packages have multiple parts (parts have an explicit meaning when used in the context of packages; essentially, parts are files that are zipped together to comprise a package). If a document contains paragraphs that are formatted with styles, there will be a document part that contains paragraphs that have styles applied to them. There will also be a style part that contains the styles that are referred to by the document.

When accessing packages, it is important that you do so through the relationships between parts, rather than using an arbitrary path. This issue is beyond the scope of the Manipulating Content in a WordprocessingML Document tutorial, but the example programs that are included in this tutorial demonstrate the correct approach.

A Document that Uses Styles

The WordML example presented in the Shape of WordprocessingML Documents (C#) topic is a very simple one. The following document is more complicated: It has paragraphs that are formatted with styles. The easiest way to see the XML that makes up an Office Open XML document is to run the Example that Outputs Office Open XML Document Parts (C#).

In the following document, the first paragraph has the style `Heading1`. There are a number of paragraphs that have the default style. There are also a number of paragraphs that have the style `Code`. Because of this relative complexity, this is a more interesting document to parse with LINQ to XML.

In those paragraphs with non-default styles, the paragraph elements have a child element named `w:pPr`, which in turn has a child element `w:pStyle`. That element has an attribute, `w:val`, which contains the style name. If the paragraph has the default style, it means that the paragraph element does not have a `w:p.Pr` child element.

```
<?xml version="1.0" encoding="utf-8"?>
<w:document
    xmlns:ve="http://schemas.openxmlformats.org/markup-compatibility/2006"
    xmlns:o="urn:schemas-microsoft-com:office:office"
    xmlns:r="http://schemas.openxmlformats.org/officeDocument/2006/relationships"
    xmlns:m="http://schemas.openxmlformats.org/officeDocument/2006/math"
    xmlns:v="urn:schemas-microsoft-com:vml"
    xmlns:wp="http://schemas.openxmlformats.org/drawingml/2006/wordprocessingDrawing"
    xmlns:w10="urn:schemas-microsoft-com:office:word"
    xmlns:w="http://schemas.openxmlformats.org/wordprocessingml/2006/main"
    xmlns:wne="http://schemas.microsoft.com/office/word/2006/wordml">
  <w:body>
    <w:p w:rsidR="00A75AE0" w:rsidRDefault="00A75AE0" w:rsidP="006027C7">
      <w:pPr>
        <w:pStyle w:val="Heading1" />
      </w:pPr>
      <w:r>
        <w:t>Parsing WordprocessingML with LINQ to XML</w:t>
      </w:r>
    </w:p>
    <w:p w:rsidR="00A75AE0" w:rsidRDefault="00A75AE0" />
    <w:p w:rsidR="00A75AE0" w:rsidRDefault="00A75AE0">
      <w:r>
        <w:t>The following example prints to the console.</w:t>
      </w:r>
    </w:p>
    <w:p w:rsidR="00A75AE0" w:rsidRDefault="00A75AE0" />
```

```
<w:p w:rsidR="00A75AE0" w:rsidRDefault="00A75AE0" />
<w:p w:rsidR="00A75AE0" w:rsidRDefault="00A75AE0" w:rsidP="006027C7">
  <w:pPr>
    <w:pStyle w:val="Code" />
  </w:pPr>
  <w:r>
    <w:t>using System;</w:t>
  </w:r>
</w:p>
<w:p w:rsidR="00A75AE0" w:rsidRDefault="00A75AE0" w:rsidP="006027C7">
  <w:pPr>
    <w:pStyle w:val="Code" />
  </w:pPr>
</w:p>
<w:p w:rsidR="00A75AE0" w:rsidRPr="00876F34" w:rsidRDefault="00A75AE0" w:rsidP="006027C7">
  <w:pPr>
    <w:pStyle w:val="Code" />
  </w:pPr>
  <w:r w:rsidRPr="00876F34">
    <w:t>class Program {</w:t>
  </w:r>
</w:p>
<w:p w:rsidR="00A75AE0" w:rsidRPr="00876F34" w:rsidRDefault="00A75AE0" w:rsidP="006027C7">
  <w:pPr>
    <w:pStyle w:val="Code" />
  </w:pPr>
  <w:r w:rsidRPr="00876F34">
    <w:t xml:space="preserve">    public static void </w:t>
  </w:r>
  <w:smartTag w:uri="urn:schemas-microsoft-com:office:smarttags" w:element="place">
    <w:r w:rsidRPr="00876F34">
      <w:t>Main</w:t>
    </w:r>
  </w:smartTag>
  <w:r w:rsidRPr="00876F34">
    <w:t>(string[] args) {</w:t>
  </w:r>
</w:p>
<w:p w:rsidR="00A75AE0" w:rsidRPr="00876F34" w:rsidRDefault="00A75AE0" w:rsidP="006027C7">
  <w:pPr>
    <w:pStyle w:val="Code" />
  </w:pPr>
  <w:r w:rsidRPr="00876F34">
    <w:t xml:space="preserve">        Console.WriteLine("Hello World");</w:t>
  </w:r>
</w:p>
<w:p w:rsidR="00A75AE0" w:rsidRPr="00876F34" w:rsidRDefault="00A75AE0" w:rsidP="006027C7">
  <w:pPr>
    <w:pStyle w:val="Code" />
  </w:pPr>
  <w:r w:rsidRPr="00876F34">
    <w:t xml:space="preserve">    }</w:t>
  </w:r>
</w:p>
<w:p w:rsidR="00A75AE0" w:rsidRPr="00876F34" w:rsidRDefault="00A75AE0" w:rsidP="006027C7">
  <w:pPr>
    <w:pStyle w:val="Code" />
  </w:pPr>
  <w:r w:rsidRPr="00876F34">
    <w:t>}</w:t>
  </w:r>
</w:p>
<w:p w:rsidR="00A75AE0" w:rsidRDefault="00A75AE0" />
<w:p w:rsidR="00A75AE0" w:rsidRDefault="00A75AE0">
  <w:r>
    <w:t>This example produces the following output:</w:t>
  </w:r>
</w:p>
<w:p w:rsidR="00A75AE0" w:rsidRDefault="00A75AE0" />
<w:p w:rsidR="00A75AE0" w:rsidRDefault="00A75AE0" w:rsidP="006027C7">
```

```
    <w:p w:rsidR="00A75AE0" w:rsidRDefault="00A75AE0" w:rsidP="006027C7">
      <w:pPr>
        <w:pStyle w:val="Code" />
      </w:pPr>
      <w:r>
        <w:t>Hello World</w:t>
      </w:r>
    </w:p>
    <w:sectPr w:rsidR="00A75AE0" w:rsidSect="00A75AE0">
      <w:pgSz w:w="12240" w:h="15840" />
      <w:pgMar w:top="1440" w:right="1800" w:bottom="1440" w:left="1800" w:header="720" w:footer="720"
w:gutter="0" />
      <w:cols w:space="720" />
      <w:docGrid w:linePitch="360" />
    </w:sectPr>
  </w:body>
</w:document>
```

See also

- Details of Office Open XML WordprocessingML Documents (C#)

Style Part of a WordprocessingML Document

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This topic shows an example of the style part of the Office Open XML WordprocessingML document.

Example

The following example is the XML that makes up the style part of an Office Open XML WordprocessingML document.

The default paragraph style has an element with the following opening tag:

```
<w:style w:type="paragraph" w:default="1" w:styleId="Normal">
```

You need to know this information when you write the query to find the default style identifier, so that the query can identify the style of paragraphs that have the default style.

Note that these documents are very simple when compared to typical documents that Microsoft Word generates. In many cases, Word saves a great deal of additional information, additional formatting and metadata. Furthermore, Word does not format the lines to be easily readable as in this example; instead, the XML is saved without indentation. However, all WordprocessingML documents share the same basic XML shape. Because of this, the queries presented in this tutorial will work with more complicated documents.

```
<?xml version="1.0" encoding="utf-8"?>
<w:styles
    xmlns:r="http://schemas.openxmlformats.org/officeDocument/2006/relationships"
    xmlns:w="http://schemas.openxmlformats.org/wordprocessingml/2006/main">
  <w:docDefaults>
    <w:rPrDefault>
      <w:rPr>
        <w:rFonts
            w:ascii="Times New Roman"
            w:eastAsia="Times New Roman"
            w:hAnsi="Times New Roman"
            w:cs="Times New Roman" />
        <w:sz w:val="22" />
        <w:szCs w:val="22" />
        <w:lang w:val="en-US" w:eastAsia="en-US" w:bidi="ar-SA" />
      </w:rPr>
    </w:rPrDefault>
    <w:pPrDefault />
  </w:docDefaults>
  <w:style w:type="paragraph" w:default="1" w:styleId="Normal">
    <w:name w:val="Normal" />
    <w:qFormat />
    <w:rPr>
      <w:sz w:val="24" />
      <w:szCs w:val="24" />
    </w:rPr>
  </w:style>
  <w:style w:type="paragraph" w:styleId="Heading1">
    <w:name w:val="heading 1" />
    <w:basedOn w:val="Normal" />
    <w:next w:val="Normal" />
    <w:link w:val="Heading1Char" />
    <w:uiPriority w:val="99" />
    <w:qFormat />
    <w:rsid w:val="006027C7" />
    <w:pPr>
      <w:keepNext />
      <w:spacing w:before="240" w:after="60" />
      <w:outlineLvl w:val="0" />
    </w:pPr>
    <w:rPr>
      <w:rFonts w:ascii="Arial" w:hAnsi="Arial" w:cs="Arial" />
      <w:b />
      <w:bCs />
      <w:kern w:val="32" />
      <w:sz w:val="32" />
      <w:szCs w:val="32" />
    </w:rPr>
  </w:style>
  <w:style w:type="character" w:default="1" w:styleId="DefaultParagraphFont">
    <w:name w:val="Default Paragraph Font" />
    <w:uiPriority w:val="99" />
    <w:semiHidden />
  </w:style>
  <w:style w:type="table" w:default="1" w:styleId="TableNormal">
    <w:name w:val="Normal Table" />
    <w:uiPriority w:val="99" />
    <w:semiHidden />
    <w:unhideWhenUsed />
    <w:qFormat />
    <w:tblPr>
      <w:tblInd w:w="0" w:type="dxa" />
      <w:tblCellMar>
        <w:top w:w="0" w:type="dxa" />
        <w:left w:w="108" w:type="dxa" />
        <w:bottom w:w="0" w:type="dxa" />
        <w:right w:w="108" w:type="dxa" />
      </w:tblCellMar>
    </w:tblPr>
  </w:style>
  <w:style w:type="numbering" w:default="1" w:styleId="NoList">
    <w:name w:val="No List" />
    <w:uiPriority w:val="99" />
    <w:semiHidden />
    <w:unhideWhenUsed />
  </w:style>
  <w:style w:type="character" w:customStyle="1" w:styleId="Heading1Char">
    <w:name w:val="Heading 1 Char" />
    <w:basedOn w:val="DefaultParagraphFont" />
    <w:link w:val="Heading1" />
    <w:uiPriority w:val="9" />
    <w:rsid w:val="009765E3" />
    <w:rPr>
      <w:rFonts
          w:asciiTheme="majorHAnsi"
          w:eastAsiaTheme="majorEastAsia"
          w:hAnsiTheme="majorHAnsi"
          w:cstheme="majorBidi" />
      <w:b />
      <w:bCs />
      <w:kern w:val="32" />
      <w:sz w:val="32" />
      <w:szCs w:val="32" />
    </w:rPr>
  </w:style>
  <w:style w:type="paragraph" w:customStyle="1" w:styleId="Code">
    <w:name w:val="Code" />
    <w:aliases w:val="c" />
    <w:uiPriority w:val="99" />
    <w:rsid w:val="006027C7" />
    <w:pPr>
      <w:spacing w:after="60" w:line="300" w:lineRule="exact" />
    </w:pPr>
```

```
      <w:rPr>
        <w:rFonts w:ascii="Courier New" w:hAnsi="Courier New" />
        <w:noProof />
        <w:color w:val="000080" />
        <w:sz w:val="20" />
        <w:szCs w:val="20" />
      </w:rPr>
    </w:style>
  </w:styles>
```

See also

- Details of Office Open XML WordprocessingML Documents (C#)

Example that Outputs Office Open XML Document Parts (C#)

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This topic shows how to open an Office Open XML document and access parts within it.

Example

The following example opens an Office Open XML document, and prints the document part and the style part to the console.

This example uses classes from the WindowsBase assembly. It uses types in the System.IO.Packaging namespace.

```
const string fileName = "SampleDoc.docx";

const string documentRelationshipType =
  "http://schemas.openxmlformats.org/officeDocument/2006/relationships/officeDocument";
const string stylesRelationshipType =
  "http://schemas.openxmlformats.org/officeDocument/2006/relationships/styles";
const string wordmlNamespace =
  "http://schemas.openxmlformats.org/wordprocessingml/2006/main";
XNamespace w = wordmlNamespace;

using (Package wdPackage = Package.Open(fileName, FileMode.Open, FileAccess.Read))
{
    PackageRelationship docPackageRelationship =
      wdPackage.GetRelationshipsByType(documentRelationshipType).FirstOrDefault();
    if (docPackageRelationship != null)
    {
        Uri documentUri = PackUriHelper.ResolvePartUri(new Uri("/", UriKind.Relative),
          docPackageRelationship.TargetUri);
        PackagePart documentPart = wdPackage.GetPart(documentUri);

        //  Load the document XML in the part into an XDocument instance.
        XDocument xdoc = XDocument.Load(XmlReader.Create(documentPart.GetStream()));

        Console.WriteLine("TargetUri:{0}", docPackageRelationship.TargetUri);
        Console.WriteLine("==================================================================");
        Console.WriteLine(xdoc.Root);
        Console.WriteLine();

        //  Find the styles part. There will only be one.
        PackageRelationship styleRelation =
          documentPart.GetRelationshipsByType(stylesRelationshipType).FirstOrDefault();
        if (styleRelation != null)
        {
            Uri styleUri = PackUriHelper.ResolvePartUri(documentUri, styleRelation.TargetUri);
            PackagePart stylePart = wdPackage.GetPart(styleUri);

            //  Load the style XML in the part into an XDocument instance.
            XDocument styleDoc = XDocument.Load(XmlReader.Create(stylePart.GetStream()));

            Console.WriteLine("TargetUri:{0}", styleRelation.TargetUri);
            Console.WriteLine("==================================================================");
            Console.WriteLine(styleDoc.Root);
            Console.WriteLine();
        }
    }
}
```

See also

- Details of Office Open XML WordprocessingML Documents (C#)

Modifying XML Trees (LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

LINQ to XML is an in-memory store for an XML tree. After you load or parse an XML tree from a source, LINQ to XML lets you modify that tree in place, and then serialize the tree, perhaps saving it to a file or sending it to a remote server.

When you modify a tree in place, you use certain methods, such as Add.

However, there is another approach, which is to use functional construction to generate a new tree with a different shape. Depending on the types of changes that you need to make to your XML tree, and depending on the size of the tree, this approach can be more robust and easier to develop. The first topic in this section compares these two approaches.

In This Section

TOPIC	DESCRIPTION
In-Memory XML Tree Modification vs. Functional Construction (LINQ to XML) (C#)	Compares modifying an XML tree in memory to functional construction.
Adding Elements, Attributes, and Nodes to an XML Tree (C#)	Provides information about adding elements, attributes, or nodes to an XML tree.
Modifying Elements, Attributes, and Nodes in an XML Tree	Provides information about modifying existing elements, attributes, or nodes.
Removing Elements, Attributes, and Nodes from an XML Tree (C#)	Provides information about removing elements, attributes, or nodes from the XML tree.
Maintaining Name/Value Pairs (C#)	Describes how to maintain application information that is best kept as name/value pairs, such as configuration information or global settings.
How to: Change the Namespace for an Entire XML Tree (C#)	Shows how to move an XML tree from one namespace into another.

See also

- Programming Guide (LINQ to XML) (C#)

In-Memory XML Tree Modification vs. Functional Construction (LINQ to XML) (C#)

1/23/2019 • 3 minutes to read • Edit Online

Modifying an XML tree in place is a traditional approach to changing the shape of an XML document. A typical application loads a document into a data store such as DOM or LINQ to XML; uses a programming interface to insert nodes, delete nodes, or change the content of nodes; and then saves the XML to a file or transmits it over a network.

LINQ to XML enables another approach that is useful in many scenarios: *functional construction*. Functional construction treats modifying data as a problem of transformation, rather than as detailed manipulation of a data store. If you can take a representation of data and transform it efficiently from one form to another, the result is the same as if you took one data store and manipulated it in some way to take another shape. A key to the functional construction approach is to pass the results of queries to XDocument and XElement constructors.

In many cases you can write the transformational code in a fraction of the time that it would take to manipulate the data store, and that code is more robust and easier to maintain. In these cases, even though the transformational approach can take more processing power, it is a more effective way to modify data. If a developer is familiar with the functional approach, the resulting code in many cases is easier to understand. It is easy to find the code that modifies each part of the tree.

The approach where you modify an XML tree in-place is more familiar to many DOM programmers, whereas code written using the functional approach might look unfamiliar to a developer who doesn't yet understand that approach. If you have to only make a small modification to a large XML tree, the approach where you modify a tree in place in many cases will take less CPU time.

This topic provides an example that is implemented with both approaches.

Transforming Attributes into Elements

For this example, suppose you want to modify the following simple XML document so that the attributes become elements. This topic first presents the traditional in-place modification approach. It then shows the functional construction approach.

```
<?xml version="1.0" encoding="utf-8" ?>
<Root Data1="123" Data2="456">
  <Child1>Content</Child1>
</Root>
```

Modifying the XML Tree

You can write some procedural code to create elements from the attributes, and then delete the attributes, as follows:

```
XElement root = XElement.Load("Data.xml");
foreach (XAttribute att in root.Attributes()) {
    root.Add(new XElement(att.Name, (string)att));
}
root.Attributes().Remove();
Console.WriteLine(root);
```

This code produces the following output:

```
<Root>
  <Child1>Content</Child1>
  <Data1>123</Data1>
  <Data2>456</Data2>
</Root>
```

Functional Construction Approach

By contrast, a functional approach consists of code to form a new tree, picking and choosing elements and attributes from the source tree, and transforming them as appropriate as they are added to the new tree. The functional approach looks like the following:

```
XElement root = XElement.Load("Data.xml");
XElement newTree = new XElement("Root",
    root.Element("Child1"),
    from att in root.Attributes()
    select new XElement(att.Name, (string)att)
);
Console.WriteLine(newTree);
```

This example outputs the same XML as the first example. However, notice that you can actually see the resulting structure of the new XML in the functional approach. You can see the creation of the `Root` element, the code that pulls the `Child1` element from the source tree, and the code that transforms the attributes from the source tree to elements in the new tree.

The functional example in this case is not any shorter than the first example, and it is not really any simpler. However, if you have many changes to make to an XML tree, the non functional approach will become quite complex and somewhat obtuse. In contrast, when using the functional approach, you still just form the desired XML, embedding queries and expressions as appropriate, to pull in the desired content. The functional approach yields code that is easier to maintain.

Notice that in this case the functional approach probably would not perform quite as well as the tree manipulation approach. The main issue is that the functional approach creates more short lived objects. However, the tradeoff is an effective one if using the functional approach allows for greater programmer productivity.

This is a very simple example, but it serves to show the difference in philosophy between the two approaches. The functional approach yields greater productivity gains for transforming larger XML documents.

See also

- Modifying XML Trees (LINQ to XML) (C#)

Adding Elements, Attributes, and Nodes to an XML Tree (C#)

1/23/2019 • 2 minutes to read • Edit Online

You can add content (elements, attributes, comments, processing instructions, text, and CDATA) to an existing XML tree.

Methods for Adding Content

The following methods add child content to an XElement or an XDocument:

METHOD	DESCRIPTION
Add	Adds content at the end of the child content of the XContainer.
AddFirst	Adds content at the beginning of the child content of the XContainer.

The following methods add content as sibling nodes of an XNode. The most common node to which you add sibling content is XElement, although you can add valid sibling content to other types of nodes such as XText or XComment.

METHOD	DESCRIPTION
AddAfterSelf	Adds content after the XNode.
AddBeforeSelf	Adds content before the XNode.

Example

Description

The following example creates two XML trees, and then modifies one of the trees.

Code

```
XElement srcTree = new XElement("Root",
    new XElement("Element1", 1),
    new XElement("Element2", 2),
    new XElement("Element3", 3),
    new XElement("Element4", 4),
    new XElement("Element5", 5)
);
XElement xmlTree = new XElement("Root",
    new XElement("Child1", 1),
    new XElement("Child2", 2),
    new XElement("Child3", 3),
    new XElement("Child4", 4),
    new XElement("Child5", 5)
);
xmlTree.Add(new XElement("NewChild", "new content"));
xmlTree.Add(
    from el in srcTree.Elements()
    where (int)el > 3
    select el
);
// Even though Child9 does not exist in srcTree, the following statement will not
// throw an exception, and nothing will be added to xmlTree.
xmlTree.Add(srcTree.Element("Child9"));
Console.WriteLine(xmlTree);
```

Comments

This code produces the following output:

```
<Root>
  <Child1>1</Child1>
  <Child2>2</Child2>
  <Child3>3</Child3>
  <Child4>4</Child4>
  <Child5>5</Child5>
  <NewChild>new content</NewChild>
  <Element4>4</Element4>
  <Element5>5</Element5>
</Root>
```

See also

- Modifying XML Trees (LINQ to XML) (C#)

Modifying Elements, Attributes, and Nodes in an XML Tree

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The following table summarizes the methods and properties that you can use to modify an element, its child elements, or its attributes.

The following methods modify an XElement.

METHOD	DESCRIPTION
XElement.Parse	Replaces an element with parsed XML.
XElement.RemoveAll	Removes all content (child nodes and attributes) of an element.
XElement.RemoveAttributes	Removes the attributes of an element.
XElement.ReplaceAll	Replaces all content (child nodes and attributes) of an element.
XElement.ReplaceAttributes	Replaces the attributes of an element.
XElement.SetAttributeValue	Sets the value of an attribute. Creates the attribute if it doesn't exist. If the value is set to `null`, removes the attribute.
XElement.SetElementValue	Sets the value of a child element. Creates the element if it doesn't exist. If the value is set to `null`, removes the element.
XElement.Value	Replaces the content (child nodes) of an element with the specified text.
XElement.SetValue	Sets the value of an element.

The following methods modify an XAttribute.

METHOD	DESCRIPTION
XAttribute.Value	Sets the value of an attribute.
XAttribute.SetValue	Sets the value of an attribute.

The following methods modify an XNode (including an XElement or XDocument).

METHOD	DESCRIPTION
XNode.ReplaceWith	Replaces a node with new content.

The following methods modify an XContainer (an XElement or XDocument).

METHOD	DESCRIPTION
XContainer.ReplaceNodes	Replaces the children nodes with new content.

See also

- Modifying XML Trees (LINQ to XML) (C#)

Removing Elements, Attributes, and Nodes from an XML Tree (C#)

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You can modify an XML tree, removing elements, attributes, and other types of nodes.

Removing a single element or a single attribute from an XML document is straightforward. However, when removing collections of elements or attributes, you should first materialize a collection into a list, and then delete the elements or attributes from the list. The best approach is to use the Remove extension method, which will do this for you.

The main reason for doing this is that most of the collections you retrieve from an XML tree are yielded using deferred execution. If you do not first materialize them into a list, or if you do not use the extension methods, it is possible to encounter a certain class of bugs. For more information, see Mixed Declarative Code/Imperative Code Bugs (LINQ to XML) (C#).

The following methods remove nodes and attributes from an XML tree.

METHOD	DESCRIPTION
XAttribute.Remove	Removes an XAttribute from its parent.
XContainer.RemoveNodes	Removes the child nodes from an XContainer.
XElement.RemoveAll	Removes content and attributes from an XElement.
XElement.RemoveAttributes	Removes the attributes of an XElement.
XElement.SetAttributeValue	If you pass `null` for value, then removes the attribute.
XElement.SetElementValue	If you pass `null` for value, then removes the child element.
XNode.Remove	Removes an XNode from its parent.
Extensions.Remove	Removes every attribute or element in the source collection from its parent element.

Example

Description

This example demonstrates three approaches to removing elements. First, it removes a single element. Second, it retrieves a collection of elements, materializes them using the Enumerable.ToList operator, and removes the collection. Finally, it retrieves a collection of elements and removes them using the Remove extension method.

For more information on the ToList operator, see Converting Data Types (C#).

Code

```
XElement root = XElement.Parse(@"<Root>
    <Child1>
        <GrandChild1/>
        <GrandChild2/>
        <GrandChild3/>
    </Child1>
    <Child2>
        <GrandChild4/>
        <GrandChild5/>
        <GrandChild6/>
    </Child2>
    <Child3>
        <GrandChild7/>
        <GrandChild8/>
        <GrandChild9/>
    </Child3>
</Root>");
root.Element("Child1").Element("GrandChild1").Remove();
root.Element("Child2").Elements().ToList().Remove();
root.Element("Child3").Elements().Remove();
Console.WriteLine(root);
```

Comments

This code produces the following output:

```
<Root>
  <Child1>
    <GrandChild2 />
    <GrandChild3 />
  </Child1>
  <Child2 />
  <Child3 />
</Root>
```

Notice that the first grandchild element has been removed from `Child1`. All grandchildren elements have been removed from `Child2` and from `Child3`.

See also

- Modifying XML Trees (LINQ to XML) (C#)

Maintaining Name/Value Pairs (C#)

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Many applications have to maintain information that is best kept as name/value pairs. This information might be configuration information or global settings. LINQ to XML contains some methods that make it easy to keep a set of name/value pairs. You can either keep the information as attributes or as a set of child elements.

One difference between keeping the information as attributes or as child elements is that attributes have the constraint that there can be only one attribute with a particular name for an element. This limitation does not apply to child elements.

SetAttributeValue and SetElementValue

The two methods that facilitate keeping name/value pairs are SetAttributeValue and SetElementValue. These two methods have similar semantics.

SetAttributeValue can add, modify, or remove attributes of an element.

- If you call SetAttributeValue with a name of an attribute that does not exist, the method creates a new attribute and adds it to the specified element.
- If you call SetAttributeValue with a name of an existing attribute and with some specified content, the contents of the attribute are replaced with the specified content.
- If you call SetAttributeValue with a name of an existing attribute, and specify null for the content, the attribute is removed from its parent.

SetElementValue can add, modify, or remove child elements of an element.

- If you call SetElementValue with a name of a child element that does not exist, the method creates a new element and adds it to the specified element.
- If you call SetElementValue with a name of an existing element and with some specified content, the contents of the element are replaced with the specified content.
- If you call SetElementValue with a name of an existing element, and specify null for the content, the element is removed from its parent.

Example

The following example creates an element with no attributes. It then uses the SetAttributeValue method to create and maintain a list of name/value pairs.

```
// Create an element with no content.
XElement root = new XElement("Root");

// Add a number of name/value pairs as attributes.
root.SetAttributeValue("Top", 22);
root.SetAttributeValue("Left", 20);
root.SetAttributeValue("Bottom", 122);
root.SetAttributeValue("Right", 300);
root.SetAttributeValue("DefaultColor", "Color.Red");
Console.WriteLine(root);

// Replace the value of Top.
root.SetAttributeValue("Top", 10);
Console.WriteLine(root);

// Remove DefaultColor.
root.SetAttributeValue("DefaultColor", null);
Console.WriteLine(root);
```

This example produces the following output:

```
<Root Top="22" Left="20" Bottom="122" Right="300" DefaultColor="Color.Red" />
<Root Top="10" Left="20" Bottom="122" Right="300" DefaultColor="Color.Red" />
<Root Top="10" Left="20" Bottom="122" Right="300" />
```

Example

The following example creates an element with no child elements. It then uses the SetElementValue method to create and maintain a list of name/value pairs.

```
// Create an element with no content.
XElement root = new XElement("Root");

// Add a number of name/value pairs as elements.
root.SetElementValue("Top", 22);
root.SetElementValue("Left", 20);
root.SetElementValue("Bottom", 122);
root.SetElementValue("Right", 300);
root.SetElementValue("DefaultColor", "Color.Red");
Console.WriteLine(root);
Console.WriteLine("----");

// Replace the value of Top.
root.SetElementValue("Top", 10);
Console.WriteLine(root);
Console.WriteLine("----");

// Remove DefaultColor.
root.SetElementValue("DefaultColor", null);
Console.WriteLine(root);
```

This example produces the following output:

```
<Root>
  <Top>22</Top>
  <Left>20</Left>
  <Bottom>122</Bottom>
  <Right>300</Right>
  <DefaultColor>Color.Red</DefaultColor>
</Root>
----
<Root>
  <Top>10</Top>
  <Left>20</Left>
  <Bottom>122</Bottom>
  <Right>300</Right>
  <DefaultColor>Color.Red</DefaultColor>
</Root>
----
<Root>
  <Top>10</Top>
  <Left>20</Left>
  <Bottom>122</Bottom>
  <Right>300</Right>
</Root>
```

See also

- SetAttributeValue
- SetElementValue
- Modifying XML Trees (LINQ to XML) (C#)

How to: Change the Namespace for an Entire XML Tree (C#)

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You sometimes have to programmatically change the namespace for an element or an attribute. LINQ to XML makes this easy. The XElement.Name property can be set. The XAttribute.Name property cannot be set, but you can easily copy the attributes into a System.Collections.Generic.List<T>, remove the existing attributes, and then add new attributes that are in the new desired namespace.

For more information, see Working with XML Namespaces (C#).

Example

The following code creates two XML trees in no namespace. It then changes the namespace of each of the trees, and combines them into a single tree.

```
XElement tree1 = new XElement("Data",
    new XElement("Child", "content",
        new XAttribute("MyAttr", "content")
    )
);
XElement tree2 = new XElement("Data",
    new XElement("Child", "content",
        new XAttribute("MyAttr", "content")
    )
);
XNamespace aw = "http://www.adventure-works.com";
XNamespace ad = "http://www.adatum.com";
// change the namespace of every element and attribute in the first tree
foreach (XElement el in tree1.DescendantsAndSelf())
{
    el.Name = aw.GetName(el.Name.LocalName);
    List<XAttribute> atList = el.Attributes().ToList();
    el.Attributes().Remove();
    foreach (XAttribute at in atList)
        el.Add(new XAttribute(aw.GetName(at.Name.LocalName), at.Value));
}
// change the namespace of every element and attribute in the second tree
foreach (XElement el in tree2.DescendantsAndSelf())
{
    el.Name = ad.GetName(el.Name.LocalName);
    List<XAttribute> atList = el.Attributes().ToList();
    el.Attributes().Remove();
    foreach (XAttribute at in atList)
        el.Add(new XAttribute(ad.GetName(at.Name.LocalName), at.Value));
}
// add attribute namespaces so that the tree will be serialized with
// the aw and ad namespace prefixes
tree1.Add(
    new XAttribute(XNamespace.Xmlns + "aw", "http://www.adventure-works.com")
);
tree2.Add(
    new XAttribute(XNamespace.Xmlns + "ad", "http://www.adatum.com")
);
// create a new composite tree
XElement root = new XElement("Root",
    tree1,
    tree2
);
Console.WriteLine(root);
```

This example produces the following output:

```
<Root>
  <aw:Data xmlns:aw="http://www.adventure-works.com">
    <aw:Child aw:MyAttr="content">content</aw:Child>
  </aw:Data>
  <ad:Data xmlns:ad="http://www.adatum.com">
    <ad:Child ad:MyAttr="content">content</ad:Child>
  </ad:Data>
</Root>
```

See also

- Modifying XML Trees (LINQ to XML) (C#)

Performance (LINQ to XML) (C#)

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This section provides information about performance in LINQ to XML, specifically the performance of functional construction and queries.

In This Section

Performance of Chained Queries (LINQ to XML) (C#)
Provides performance information about chained LINQ to XML queries.

Atomized XName and XNamespace Objects (LINQ to XML) (C#)
Provides performance information about the atomization of XName and XNamespace objects.

Pre-Atomization of XName Objects (LINQ to XML) (C#)
Describes a technique to pre-atomize XName and XNamespace objects. This can significantly improve performance in some scenarios.

Statically Compiled Queries (LINQ to XML) (C#)
Provides performance information about statically compiled queries, in contrast to the parsing and processing that must be done by an XPath expression evaluator.

See also

- Programming Guide (LINQ to XML) (C#)

Performance of Chained Queries (LINQ to XML) (C#)

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One of the most important benefits of LINQ (and LINQ to XML) is that chained queries can perform as well as a single larger, more complicated query.

A chained query is a query that uses another query as its source. For example, in the following simple code, `query2` has `query1` as its source:

```
XElement root = new XElement("Root",
    new XElement("Child", 1),
    new XElement("Child", 2),
    new XElement("Child", 3),
    new XElement("Child", 4)
);

var query1 = from x in root.Elements("Child")
             where (int)x >= 3
             select x;

var query2 = from e in query1
             where (int)e % 2 == 0
             select e;

foreach (var i in query2)
    Console.WriteLine("{0}", (int)i);
```

This example produces the following output:

```
4
```

This chained query provides the same performance profile as iterating through a linked list.

- The Elements axis has essentially the same performance as iterating through a linked list. Elements is implemented as an iterator with deferred execution. This means that it does some work in addition to iterating through the linked list, such as allocating the iterator object and keeping track of execution state. This work can be divided into two categories: the work that is done at the time the iterator is set up, and the work that is done during each iteration. The setup work is a small, fixed amount of work and the work done during each iteration is proportional to the number of items in the source collection.
- In `query1`, the `where` clause causes the query to call the Where method. This method is also implemented as an iterator. The setup work consists of instantiating the delegate that will reference the lambda expression, plus the normal setup for an iterator. With each iteration, the delegate is called to execute the predicate. The setup work and the work done during each iteration is the similar to the work done while iterating through the axis.
- In `query1`, the select clause causes the query to call the Select method. This method has the same performance profile as the Where method.
- In `query2`, both the `where` clause and the `select` clause have the same performance profile as in `query1`.

The iteration through `query2` is therefore directly proportional to the number of items in the source of the first query, in other words, linear time. A corresponding Visual Basic example would have the same performance profile.

For more information on iterators, see yield.

For a more detailed tutorial on chaining queries together, see Tutorial: Chaining Queries Together.

See also

- Performance (LINQ to XML) (C#)

Atomized XName and XNamespace Objects (LINQ to XML) (C#)

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XName and XNamespace objects are *atomized*; that is, if they contain the same qualified name, they refer to the same object. This yields performance benefits for queries: When you compare two atomized names for equality, the underlying intermediate language only has to determine whether the two references point to the same object. The underlying code does not have to do string comparisons, which would be time consuming.

Atomization Semantics

Atomization means that if two XName objects have the same local name, and they are in the same namespace, they share the same instance. In the same way, if two XNamespace objects have the same namespace URI, they share the same instance.

For a class to enable atomized objects, the constructor for the class must be private, not public. This is because if the constructor were public, you could create a non-atomized object. The XName and XNamespace classes implement an implicit conversion operator to convert a string into an XName or XNamespace. This is how you get an instance of these objects. You cannot get an instance by using a constructor, because the constructor is inaccessible.

XName and XNamespace also implement the equality and inequality operators, to determine whether the two objects being compared are references to the same instance.

Example

The following code creates some XElement objects and demonstrates that identical names share the same instance.

```
XElement r1 = new XElement("Root", "data1");
XElement r2 = XElement.Parse("<Root>data2</Root>");

if ((object)r1.Name == (object)r2.Name)
    Console.WriteLine("r1 and r2 have names that refer to the same instance.");
else
    Console.WriteLine("Different");

XName n = "Root";

if ((object)n == (object)r1.Name)
    Console.WriteLine("The name of r1 and the name in 'n' refer to the same instance.");
else
    Console.WriteLine("Different");
```

This example produces the following output:

```
r1 and r2 have names that refer to the same instance.
The name of r1 and the name in 'n' refer to the same instance.
```

As mentioned earlier, the benefit of atomized objects is that when you use one of the axis methods that take an XName as a parameter, the axis method only has to determine that two names reference the same instance to select the desired elements.

The following example passes an XName to the Descendants method call, which then has better performance because of the atomization pattern.

```
XElement root = new XElement("Root",
    new XElement("C1", 1),
    new XElement("Z1",
        new XElement("C1", 2),
        new XElement("C1", 1)
    )
);

var query = from e in root.Descendants("C1")
            where (int)e == 1
            select e;

foreach (var z in query)
    Console.WriteLine(z);
```

This example produces the following output:

```
<C1>1</C1>
<C1>1</C1>
```

See also

- Performance (LINQ to XML) (C#)

Pre-Atomization of XName Objects (LINQ to XML) (C#)

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One way to improve performance in LINQ to XML is to pre-atomize XName objects. Pre-atomization means that you assign a string to an XName object before you create the XML tree by using the constructors of the XElement and XAttribute classes. Then, instead of passing a string to the constructor, which would use the implicit conversion from string to XName, you pass the initialized XName object.

This improves performance when you create a large XML tree in which specific names are repeated. To do this, you declare and initialize XName objects before you construct the XML tree, and then use the XName objects instead of specifying strings for the element and attribute names. This technique can yield significant performance gains if you are creating a large number of elements (or attributes) with the same name.

You should test pre-atomization with your scenario to decide if you should use it.

Example

The following example demonstrates this.

```
XName Root = "Root";
XName Data = "Data";
XName ID = "ID";

XElement root = new XElement(Root,
    new XElement(Data,
        new XAttribute(ID, "1"),
        "4,100,000"),
    new XElement(Data,
        new XAttribute(ID, "2"),
        "3,700,000"),
    new XElement(Data,
        new XAttribute(ID, "3"),
        "1,150,000")
);

Console.WriteLine(root);
```

This example produces the following output:

```
<Root>
  <Data ID="1">4,100,000</Data>
  <Data ID="2">3,700,000</Data>
  <Data ID="3">1,150,000</Data>
</Root>
```

The following example shows the same technique where the XML document is in a namespace:

```
XNamespace aw = "http://www.adventure-works.com";
XName Root = aw + "Root";
XName Data = aw + "Data";
XName ID = "ID";

XElement root = new XElement(Root,
    new XAttribute(XNamespace.Xmlns + "aw", aw),
    new XElement(Data,
        new XAttribute(ID, "1"),
        "4,100,000"),
    new XElement(Data,
        new XAttribute(ID, "2"),
        "3,700,000"),
    new XElement(Data,
        new XAttribute(ID, "3"),
        "1,150,000")
);

Console.WriteLine(root);
```

This example produces the following output:

```
<aw:Root xmlns:aw="http://www.adventure-works.com">
  <aw:Data ID="1">4,100,000</aw:Data>
  <aw:Data ID="2">3,700,000</aw:Data>
  <aw:Data ID="3">1,150,000</aw:Data>
</aw:Root>
```

The following example is more similar to what you will likely encounter in the real world. In this example, the content of the element is supplied by a query:

```
XName Root = "Root";
XName Data = "Data";
XName ID = "ID";

DateTime t1 = DateTime.Now;
XElement root = new XElement(Root,
    from i in System.Linq.Enumerable.Range(1, 100000)
    select new XElement(Data,
        new XAttribute(ID, i),
        i * 5)
);
DateTime t2 = DateTime.Now;

Console.WriteLine("Time to construct:{0}", t2 - t1);
```

The previous example performs better than the following example, in which names are not pre-atomized:

```
DateTime t1 = DateTime.Now;
XElement root = new XElement("Root",
    from i in System.Linq.Enumerable.Range(1, 100000)
    select new XElement("Data",
        new XAttribute("ID", i),
        i * 5)
);
DateTime t2 = DateTime.Now;

Console.WriteLine("Time to construct:{0}", t2 - t1);
```

See also

- Performance (LINQ to XML) (C#)
- Atomized XName and XNamespace Objects (LINQ to XML) (C#)

Statically Compiled Queries (LINQ to XML) (C#)

1/23/2019 • 2 minutes to read • Edit Online

One of the most important performance benefits LINQ to XML, as opposed to XmlDocument, is that queries in LINQ to XML are statically compiled, whereas XPath queries must be interpreted at run time. This feature is built in to LINQ to XML, so you do not have to perform extra steps to take advantage of it, but it is helpful to understand the distinction when choosing between the two technologies. This topic explains the difference.

Statically Compiled Queries vs. XPath

The following example shows how to get the descendant elements with a specified name, and with an attribute with a specified value.

The following is the equivalent XPath expression:

```
//Address[@Type='Shipping']
```

```
XDocument po = XDocument.Load("PurchaseOrders.xml");

IEnumerable<XElement> list1 =
    from el in po.Descendants("Address")
    where (string)el.Attribute("Type") == "Shipping"
    select el;

foreach (XElement el in list1)
    Console.WriteLine(el);
```

The query expression in this example is re-written by the compiler to method-based query syntax. The following example, which is written in method-based query syntax, produces the same results as the previous one:

```
XDocument po = XDocument.Load("PurchaseOrders.xml");

IEnumerable<XElement> list1 =
    po
    .Descendants("Address")
    .Where(el => (string)el.Attribute("Type") == "Shipping");

foreach (XElement el in list1)
    Console.WriteLine(el);
```

The Where method is an extension method. For more information, see Extension Methods. Because Where is an extension method, the query above is compiled as though it were written as follows:

```
XDocument po = XDocument.Load("PurchaseOrders.xml");

IEnumerable<XElement> list1 =
    System.Linq.Enumerable.Where(
        po.Descendants("Address"),
        el => (string)el.Attribute("Type") == "Shipping");

foreach (XElement el in list1)
    Console.WriteLine(el);
```

This example produces exactly the same results as the previous two examples. This illustrates the fact that queries are effectively compiled into statically linked method calls. This, combined with the deferred execution semantics of iterators, improves performance. For more information about the deferred execution semantics of iterators, see Deferred Execution and Lazy Evaluation in LINQ to XML (C#).

NOTE

These examples are representative of the code that the compiler might write. The actual implementation might differ slightly from these examples, but the performance will be the same or similar to these examples.

Executing XPath Expressions with XmlDocument

The following example uses XmlDocument to accomplish the same results as the previous examples:

```
XmlReader reader = XmlReader.Create("PurchaseOrders.xml");
XmlDocument doc = new XmlDocument();
doc.Load(reader);
XmlNodeList nl = doc.SelectNodes(".//Address[@Type='Shipping']");
foreach (XmlNode n in nl)
    Console.WriteLine(n.OuterXml);
reader.Close();
```

This query returns the same output as the examples that use LINQ to XML; the only difference is that LINQ to XML indents the printed XML, whereas XmlDocument does not.

However, the XmlDocument approach generally does not perform as well as LINQ to XML, because the SelectNodes method must do the following internally every time it is called:

- It parses the string that contains the XPath expression, breaking the string into tokens.
- It validates the tokens to make sure that the XPath expression is valid.
- It translates the expression into an internal expression tree.
- It iterates through the nodes, appropriately selecting the nodes for the result set based on the evaluation of the expression.

This is significantly more than the work done by the corresponding LINQ to XML query. The specific performance difference varies for different types of queries, but in general LINQ to XML queries do less work, and therefore perform better, than evaluating XPath expressions using XmlDocument.

See also

- Performance (LINQ to XML) (C#)

Advanced LINQ to XML Programming (C#)

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This section provides information that will only be applicable to advanced developers in certain LINQ to XML scenarios.

In This Section

TOPIC	DESCRIPTION
LINQ to XML Annotations	Describes how to add annotations to LINQ to XML nodes and attributes.
LINQ to XML Events (C#)	Describes how to write event handlers for events that occur when you alter an XML tree.
Programming with Nodes (C#)	Describes how to query and manipulate nodes at a finer level of granularity than elements and attributes.
Mixed Declarative Code/Imperative Code Bugs (LINQ to XML) (C#)	Describes the problems that appear when you mix declarative code (queries) with imperative code (code that modifies the XML tree).
How to: Stream XML Fragments with Access to Header Information (C#)	Describes how to stream XML fragments from an XmlReader. You can use this technique to control the memory footprint of your application.
How to: Perform Streaming Transform of Large XML Documents (C#)	Describes how to stream XML from an XmlReader, transform the XML fragment, and stream the output using XStreamingElement.
How to: Read and Write an Encoded Document (C#)	Describes how to read and write XML documents that are encoded.
Using XSLT to Transform an XML Tree (C#)	Describes how to transform an XML tree using XSLT.
How to: Use Annotations to Transform LINQ to XML Trees in an XSLT Style (C#)	Describes how annotations can be used to facilitate transforms of an XML tree.
Serializing Object Graphs that Contain XElement Objects (C#)	Describes how to serialize object graphs that contain XElement and XDocument objects.
WPF Data Binding with LINQ to XML	Describes how to use LINQ to XML as the data source for data binding in Windows Presentation Foundation applications.

See also

- Programming Guide (LINQ to XML) (C#)

LINQ to XML Annotations

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Annotations in LINQ to XML enable you to associate any arbitrary object of any arbitrary type with any XML component in an XML tree.

To add an annotation to an XML component, such as an XElement or XAttribute, you call the AddAnnotation method. You retrieve annotations by type.

Note that annotations are not part of the XML infoset; they are not serialized or deserialized.

Methods

You can use the following methods when working with annotations:

METHOD	DESCRIPTION
AddAnnotation	Adds an object to the annotation list of an XObject.
Annotation	Gets the first annotation object of the specified type from an XObject.
Annotations	Gets a collection of annotations of the specified type for an XObject.
RemoveAnnotations	Removes the annotations of the specified type from an XObject.

See also

- Advanced LINQ to XML Programming (C#)

LINQ to XML Events (C#)

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LINQ to XML events enable you to be notified when an XML tree is altered.

You can add events to an instance of any XObject. The event handler will then receive events for modifications to that XObject and any of its descendants. For example, you can add an event handler to the root of the tree, and handle all modifications to the tree from that event handler.

For examples of LINQ to XML events, see Changing and Changed.

Types and Events

You use the following types when working with events:

TYPE	DESCRIPTION
XObjectChange	Specifies the event type when an event is raised for an XObject.
XObjectChangeEventArgs	Provides data for the Changing and Changed events.

The following events are raised when you modify an XML tree:

EVENT	DESCRIPTION
Changing	Occurs just before this XObject or any of its descendants is going to change.
Changed	Occurs when an XObject has changed or any of its descendants have changed.

Example

Description

Events are useful when you want to maintain some aggregate information in an XML tree. For example, you may want maintain an invoice total that is the sum of the line items of the invoice. This example uses events to maintain the total of all of the child elements under the complex element `Items`.

Code

```
XElement root = new XElement("Root",
    new XElement("Total", "0"),
    new XElement("Items")
);
XElement total = root.Element("Total");
XElement items = root.Element("Items");
items.Changed += (object sender, XObjectChangeEventArgs cea) =>
{
    switch (cea.ObjectChange)
    {
        case XObjectChange.Add:
            if (sender is XElement)
                total.Value = ((int)total + (int)(XElement)sender).ToString();
            if (sender is XText)
                total.Value = ((int)total + (int)((XText)sender).Parent).ToString();
            break;
        case XObjectChange.Remove:
            if (sender is XElement)
                total.Value = ((int)total - (int)(XElement)sender).ToString();
            if (sender is XText)
                total.Value = ((int)total - Int32.Parse(((XText)sender).Value)).ToString();
            break;
    }
    Console.WriteLine("Changed {0} {1}",
      sender.GetType().ToString(), cea.ObjectChange.ToString());
};
items.SetElementValue("Item1", 25);
items.SetElementValue("Item2", 50);
items.SetElementValue("Item2", 75);
items.SetElementValue("Item3", 133);
items.SetElementValue("Item1", null);
items.SetElementValue("Item4", 100);
Console.WriteLine("Total:{0}", (int)total);
Console.WriteLine(root);
```

Comments

This code produces the following output:

```
Changed System.Xml.Linq.XElement Add
Changed System.Xml.Linq.XElement Add
Changed System.Xml.Linq.XText Remove
Changed System.Xml.Linq.XText Add
Changed System.Xml.Linq.XElement Add
Changed System.Xml.Linq.XElement Remove
Changed System.Xml.Linq.XElement Add
Total:308
<Root>
  <Total>308</Total>
  <Items>
    <Item2>75</Item2>
    <Item3>133</Item3>
    <Item4>100</Item4>
  </Items>
</Root>
```

See also

- Advanced LINQ to XML Programming (C#)

Programming with Nodes (C#)

1/23/2019 • 3 minutes to read • Edit Online

LINQ to XML developers who need to write programs such as an XML editor, a transform system, or a report writer often need to write programs that work at a finer level of granularity than elements and attributes. They often need to work at the node level, manipulating text nodes, processing instructions, and comments. This topic provides some details about programming at the node level.

Node Details

There are a number of details of programming that a programmer working at the node level should know.

Parent Property of Children Nodes of XDocument is Set to Null

The Parent property contains the parent XElement, not the parent node. Child nodes of XDocument have no parent XElement. Their parent is the document, so the Parent property for those nodes is set to null.

The following example demonstrates this:

```
XDocument doc = XDocument.Parse(@"<!-- a comment --><Root/>");
Console.WriteLine(doc.Nodes().OfType<XComment>().First().Parent == null);
Console.WriteLine(doc.Root.Parent == null);
```

This example produces the following output:

```
True
True
```

Adjacent Text Nodes are Possible

In a number of XML programming models, adjacent text nodes are always merged. This is sometimes called normalization of text nodes. LINQ to XML does not normalize text nodes. If you add two text nodes to the same element, it will result in adjacent text nodes. However, if you add content specified as a string rather than as an XText node, LINQ to XML might merge the string with an adjacent text node.

The following example demonstrates this:

```
XElement xmlTree = new XElement("Root", "Content");

Console.WriteLine(xmlTree.Nodes().OfType<XText>().Count());

// this does not add a new text node
xmlTree.Add("new content");
Console.WriteLine(xmlTree.Nodes().OfType<XText>().Count());

// this does add a new, adjacent text node
xmlTree.Add(new XText("more text"));
Console.WriteLine(xmlTree.Nodes().OfType<XText>().Count());
```

This example produces the following output:

```
1
1
2
```

Empty Text Nodes are Possible

In some XML programming models, text nodes are guaranteed to not contain the empty string. The reasoning is that such a text node has no impact on serialization of the XML. However, for the same reason that adjacent text nodes are possible, if you remove the text from a text node by setting its value to the empty string, the text node itself will not be deleted.

```
XElement xmlTree = new XElement("Root", "Content");
XText textNode = xmlTree.Nodes().OfType<XText>().First();

// the following line does not cause the removal of the text node.
textNode.Value = "";

XText textNode2 = xmlTree.Nodes().OfType<XText>().First();
Console.WriteLine(">>{0}<<", textNode2);
```

This example produces the following output:

```
>><<
```

An Empty Text Node Impacts Serialization

If an element contains only a child text node that is empty, it is serialized with the long tag syntax: `<Child></Child>`. If an element contains no child nodes whatsoever, it is serialized with the short tag syntax: `<Child />`.

```
XElement child1 = new XElement("Child1",
    new XText("")
);
XElement child2 = new XElement("Child2");
Console.WriteLine(child1);
Console.WriteLine(child2);
```

This example produces the following output:

```
<Child1></Child1>
<Child2 />
```

Namespaces are Attributes in the LINQ to XML Tree

Even though namespace declarations have identical syntax to attributes, in some programming interfaces, such as XSLT and XPath, namespace declarations are not considered to be attributes. However, in LINQ to XML, namespaces are stored as XAttribute objects in the XML tree. If you iterate through the attributes for an element that contains a namespace declaration, you will see the namespace declaration as one of the items in the returned collection.

The IsNamespaceDeclaration property indicates whether an attribute is a namespace declaration.

```
XElement root = XElement.Parse(
@"<Root
    xmlns='http://www.adventure-works.com'
    xmlns:fc='www.fourthcoffee.com'
    AnAttribute='abc'/>");
foreach (XAttribute att in root.Attributes())
    Console.WriteLine("{0}  IsNamespaceDeclaration:{1}", att, att.IsNamespaceDeclaration);
```

This example produces the following output:

```
xmlns="http://www.adventure-works.com"  IsNamespaceDeclaration:True
xmlns:fc="www.fourthcoffee.com"  IsNamespaceDeclaration:True
AnAttribute="abc"  IsNamespaceDeclaration:False
```

XPath Axis Methods Do Not Return Child White Space of XDocument

LINQ to XML allows for child text nodes of an XDocument, as long as the text nodes contain only white space. However, the XPath object model does not include white space as child nodes of a document, so when you iterate through the children of an XDocument using the Nodes axis, white-space text nodes will be returned. However, when you iterate through the children of an XDocument using the XPath axis methods, white-space text nodes will not be returned.

```
// Create a document with some white-space child nodes of the document.
XDocument root = XDocument.Parse(
@"<?xml version='1.0' encoding='utf-8' standalone='yes'?>

<Root/>

<!--a comment-->
", LoadOptions.PreserveWhitespace);

// count the white-space child nodes using LINQ to XML
Console.WriteLine(root.Nodes().OfType<XText>().Count());

// count the white-space child nodes using XPathEvaluate
Console.WriteLine(((IEnumerable)root.XPathEvaluate("text()")).OfType<XText>().Count());
```

This example produces the following output:

```
3
0
```

XDeclaration Objects are not Nodes

When you iterate through the children nodes of an XDocument, you will not see the XML declaration object. It is a property of the document, not a child node of it.

```
XDocument doc = new XDocument(
    new XDeclaration("1.0", "utf-8", "yes"),
    new XElement("Root")
);
doc.Save("Temp.xml");
Console.WriteLine(File.ReadAllText("Temp.xml"));

// this shows that there is only one child node of the document
Console.WriteLine(doc.Nodes().Count());
```

This example produces the following output:

```
<?xml version="1.0" encoding="utf-8" standalone="yes"?>
<Root />
1
```

See also

- Advanced LINQ to XML Programming (C#)

Mixed Declarative Code/Imperative Code Bugs (LINQ to XML) (C#)

1/23/2019 • 5 minutes to read • Edit Online

LINQ to XML contains various methods that allow you to modify an XML tree directly. You can add elements, delete elements, change the contents of an element, add attributes, and so on. This programming interface is described in Modifying XML Trees (LINQ to XML) (C#). If you are iterating through one of the axes, such as Elements, and you are modifying the XML tree as you iterate through the axis, you can end up with some strange bugs.

This problem is sometimes known as "The Halloween Problem".

Definition of the Problem

When you write some code using LINQ that iterates through a collection, you are writing code in a declarative style. It is more akin to describing *what* you want, rather that *how* you want to get it done. If you write code that 1) gets the first element, 2) tests it for some condition, 3) modifies it, and 4) puts it back into the list, then this would be imperative code. You are telling the computer *how* to do what you want done.

Mixing these styles of code in the same operation is what leads to problems. Consider the following:

Suppose you have a linked list with three items in it (a, b, and c):

```
a -> b -> c
```

Now, suppose that you want to move through the linked list, adding three new items (a', b', and c'). You want the resulting linked list to look like this:

```
a -> a' -> b -> b' -> c -> c'
```

So you write code that iterates through the list, and for every item, adds a new item right after it. What happens is that your code will first see the `a` element, and insert `a'` after it. Now, your code will move to the next node in the list, which is now `a'`! It happily adds a new item to the list, `a''`.

How would you solve this in the real world? Well, you might make a copy of the original linked list, and create a completely new list. Or if you are writing purely imperative code, you might find the first item, add the new item, and then advance twice in the linked list, advancing over the element that you just added.

Adding While Iterating

For example, suppose you want to write some code that for every element in a tree, you want to create a duplicate element:

```
XElement root = new XElement("Root",
    new XElement("A", "1"),
    new XElement("B", "2"),
    new XElement("C", "3")
);
foreach (XElement e in root.Elements())
    root.Add(new XElement(e.Name, (string)e));
```

This code goes into an infinite loop. The `foreach` statement iterates through the `Elements()` axis, adding new elements to the `doc` element. It ends up iterating also through the elements it just added. And because it allocates new objects with every iteration of the loop, it will eventually consume all available memory.

You can fix this problem by pulling the collection into memory using the ToList standard query operator, as follows:

```
XElement root = new XElement("Root",
    new XElement("A", "1"),
    new XElement("B", "2"),
    new XElement("C", "3")
);
foreach (XElement e in root.Elements().ToList())
    root.Add(new XElement(e.Name, (string)e));
Console.WriteLine(root);
```

Now the code works. The resulting XML tree is the following:

```
<Root>
  <A>1</A>
  <B>2</B>
  <C>3</C>
  <A>1</A>
  <B>2</B>
  <C>3</C>
</Root>
```

Deleting While Iterating

If you want to delete all nodes at a certain level, you might be tempted to write code like the following:

```
XElement root = new XElement("Root",
    new XElement("A", "1"),
    new XElement("B", "2"),
    new XElement("C", "3")
);
foreach (XElement e in root.Elements())
    e.Remove();
Console.WriteLine(root);
```

However, this does not do what you want. In this situation, after you have removed the first element, A, it is removed from the XML tree contained in root, and the code in the Elements method that is doing the iterating cannot find the next element.

The preceding code produces the following output:

```
<Root>
  <B>2</B>
  <C>3</C>
</Root>
```

The solution again is to call ToList to materialize the collection, as follows:

```
XElement root = new XElement("Root",
    new XElement("A", "1"),
    new XElement("B", "2"),
    new XElement("C", "3")
);
foreach (XElement e in root.Elements().ToList())
    e.Remove();
Console.WriteLine(root);
```

This produces the following output:

```
<Root />
```

Alternatively, you can eliminate the iteration altogether by calling RemoveAll on the parent element:

```
XElement root = new XElement("Root",
    new XElement("A", "1"),
    new XElement("B", "2"),
    new XElement("C", "3")
);
root.RemoveAll();
Console.WriteLine(root);
```

Why Can't LINQ Automatically Handle This?

One approach would be to always bring everything into memory instead of doing lazy evaluation. However, it would be very expensive in terms of performance and memory use. In fact, if LINQ and (LINQ to XML) were to take this approach, it would fail in real-world situations.

Another possible approach would be to put in some sort of transaction syntax into LINQ, and have the compiler attempt to analyze the code and determine if any particular collection needed to be materialized. However, attempting to determine all code that has side-effects is incredibly complex. Consider the following code:

```
var z =
    from e in root.Elements()
    where TestSomeCondition(e)
    select DoMyProjection(e);
```

Such analysis code would need to analyze the methods TestSomeCondition and DoMyProjection, and all methods that those methods called, to determine if any code had side-effects. But the analysis code could not just look for any code that had side-effects. It would need to select for just the code that had side-effects on the child elements of `root` in this situation.

LINQ to XML does not attempt to do any such analysis.

It is up to you to avoid these problems.

Guidance

First, do not mix declarative and imperative code.

Even if you know exactly the semantics of your collections and the semantics of the methods that modify the XML tree, if you write some clever code that avoids these categories of problems, your code will need to be maintained by other developers in the future, and they may not be as clear on the issues. If you mix declarative and imperative coding styles, your code will be more brittle.

If you write code that materializes a collection so that these problems are avoided, note it with comments as appropriate in your code, so that maintenance programmers will understand the issue.

Second, if performance and other considerations allow, use only declarative code. Don't modify your existing XML tree. Generate a new one.

```
XElement root = new XElement("Root",
    new XElement("A", "1"),
    new XElement("B", "2"),
    new XElement("C", "3")
);
XElement newRoot = new XElement("Root",
    root.Elements(),
    root.Elements()
);
Console.WriteLine(newRoot);
```

See also

- Advanced LINQ to XML Programming (C#)

How to: Stream XML Fragments with Access to Header Information (C#)

1/23/2019 • 3 minutes to read • Edit Online

Sometimes you have to read arbitrarily large XML files, and write your application so that the memory footprint of the application is predictable. If you attempt to populate an XML tree with a large XML file, your memory usage will be proportional to the size of the file—that is, excessive. Therefore, you should use a streaming technique instead.

One option is to write your application using XmlReader. However, you might want to use LINQ to query the XML tree. If this is the case, you can write your own custom axis method. For more information, see How to: Write a LINQ to XML Axis Method (C#).

To write your own axis method, you write a small method that uses the XmlReader to read nodes until it reaches one of the nodes in which you are interested. The method then calls ReadFrom, which reads from the XmlReader and instantiates an XML fragment. It then yields each fragment through `yield return` to the method that is enumerating your custom axis method. You can then write LINQ queries on your custom axis method.

Streaming techniques are best applied in situations where you need to process the source document only once, and you can process the elements in document order. Certain standard query operators, such as OrderBy, iterate their source, collect all of the data, sort it, and then finally yield the first item in the sequence. Note that if you use a query operator that materializes its source before yielding the first item, you will not retain a small memory footprint.

Example

Sometimes the problem gets just a little more interesting. In the following XML document, the consumer of your custom axis method also has to know the name of the customer that each item belongs to.

```xml
<?xml version="1.0" encoding="utf-8" ?>
<Root>
  <Customer>
    <Name>A. Datum Corporation</Name>
    <Item>
      <Key>0001</Key>
    </Item>
    <Item>
      <Key>0002</Key>
    </Item>
    <Item>
      <Key>0003</Key>
    </Item>
    <Item>
      <Key>0004</Key>
    </Item>
  </Customer>
  <Customer>
    <Name>Fabrikam, Inc.</Name>
    <Item>
      <Key>0005</Key>
    </Item>
    <Item>
      <Key>0006</Key>
    </Item>
    <Item>
      <Key>0007</Key>
    </Item>
    <Item>
      <Key>0008</Key>
    </Item>
  </Customer>
  <Customer>
    <Name>Southridge Video</Name>
    <Item>
      <Key>0009</Key>
    </Item>
    <Item>
      <Key>0010</Key>
    </Item>
  </Customer>
</Root>
```

The approach that this example takes is to also watch for this header information, save the header information, and then build a small XML tree that contains both the header information and the detail that you are enumerating. The axis method then yields this new, small XML tree. The query then has access to the header information as well as the detail information.

This approach has a small memory footprint. As each detail XML fragment is yielded, no references are kept to the previous fragment, and it is available for garbage collection. Note that this technique creates many short lived objects on the heap.

The following example shows how to implement and use a custom axis method that streams XML fragments from the file specified by the URI. This custom axis is specifically written such that it expects a document that has `Customer`, `Name`, and `Item` elements, and that those elements will be arranged as in the above `Source.xml` document. It is a simplistic implementation. A more robust implementation would be prepared to parse an invalid document.

```
static IEnumerable<XElement> StreamCustomerItem(string uri)
{
    using (XmlReader reader = XmlReader.Create(uri))
    {
        XElement name = null;
        XElement item = null;

        reader.MoveToContent();

        // Parse the file, save header information when encountered, and yield the
        // Item XElement objects as they are created.

        // loop through Customer elements
        while (reader.Read())
        {
            if (reader.NodeType == XmlNodeType.Element
                && reader.Name == "Customer")
            {
                // move to Name element
                while (reader.Read())
                {
                    if (reader.NodeType == XmlNodeType.Element &&
                        reader.Name == "Name")
                    {
                        name = XElement.ReadFrom(reader) as XElement;
                        break;
                    }
                }

                // loop through Item elements
                while (reader.Read())
                {
                    if (reader.NodeType == XmlNodeType.EndElement)
                        break;
                    if (reader.NodeType == XmlNodeType.Element
                        && reader.Name == "Item")
                    {
                        item = XElement.ReadFrom(reader) as XElement;
                        if (item != null) {
                            XElement tempRoot = new XElement("Root",
                                new XElement(name)
                            );
                            tempRoot.Add(item);
                            yield return item;
                        }
                    }
                }
            }
        }
    }
}

static void Main(string[] args)
{
    XElement xmlTree = new XElement("Root",
        from el in StreamCustomerItem("Source.xml")
        where (int)el.Element("Key") >= 3 && (int)el.Element("Key") <= 7
        select new XElement("Item",
            new XElement("Customer", (string)el.Parent.Element("Name")),
            new XElement(el.Element("Key"))
        )
    );
    Console.WriteLine(xmlTree);
}
```

This code produces the following output:

```
<Root>
  <Item>
    <Customer>A. Datum Corporation</Customer>
    <Key>0003</Key>
  </Item>
  <Item>
    <Customer>A. Datum Corporation</Customer>
    <Key>0004</Key>
  </Item>
  <Item>
    <Customer>Fabrikam, Inc.</Customer>
    <Key>0005</Key>
  </Item>
  <Item>
    <Customer>Fabrikam, Inc.</Customer>
    <Key>0006</Key>
  </Item>
  <Item>
    <Customer>Fabrikam, Inc.</Customer>
    <Key>0007</Key>
  </Item>
</Root>
```

See also

- Advanced LINQ to XML Programming (C#)

How to: Perform Streaming Transform of Large XML Documents (C#)

1/23/2019 • 4 minutes to read • Edit Online

Sometimes you have to transform large XML files, and write your application so that the memory footprint of the application is predictable. If you try to populate an XML tree with a very large XML file, your memory usage will be proportional to the size of the file (that is, excessive). Therefore, you should use a streaming technique instead.

Streaming techniques are best applied in situations where you need to process the source document only once, and you can process the elements in document order. Certain standard query operators, such as OrderBy, iterate their source, collect all of the data, sort it, and then finally yield the first item in the sequence. Note that if you use a query operator that materializes its source before yielding the first item, you will not retain a small memory footprint for your application.

Even if you use the technique described in How to: Stream XML Fragments with Access to Header Information (C#), if you try to assemble an XML tree that contains the transformed document, memory usage will be too great.

There are two main approaches. One approach is to use the deferred processing characteristics of XStreamingElement. Another approach is to create an XmlWriter, and use the capabilities of LINQ to XML to write elements to an XmlWriter. This topic demonstrates both approaches.

Example

The following example builds on the example in How to: Stream XML Fragments with Access to Header Information (C#).

This example uses the deferred execution capabilities of XStreamingElement to stream the output. This example can transform a very large document while maintaining a small memory footprint.

Note that the custom axis (`StreamCustomerItem`) is specifically written so that it expects a document that has `Customer`, `Name`, and `Item` elements, and that those elements will be arranged as in the following Source.xml document. A more robust implementation, however, would be prepared to parse an invalid document.

The following is the source document, Source.xml:

```xml
<?xml version="1.0" encoding="utf-8" ?>
<Root>
  <Customer>
    <Name>A. Datum Corporation</Name>
    <Item>
      <Key>0001</Key>
    </Item>
    <Item>
      <Key>0002</Key>
    </Item>
    <Item>
      <Key>0003</Key>
    </Item>
    <Item>
      <Key>0004</Key>
    </Item>
  </Customer>
  <Customer>
    <Name>Fabrikam, Inc.</Name>
    <Item>
      <Key>0005</Key>
    </Item>
    <Item>
      <Key>0006</Key>
    </Item>
    <Item>
      <Key>0007</Key>
    </Item>
    <Item>
      <Key>0008</Key>
    </Item>
  </Customer>
  <Customer>
    <Name>Southridge Video</Name>
    <Item>
      <Key>0009</Key>
    </Item>
    <Item>
      <Key>0010</Key>
    </Item>
  </Customer>
</Root>
```

```
static IEnumerable<XElement> StreamCustomerItem(string uri)
{
    using (XmlReader reader = XmlReader.Create(uri))
    {
        XElement name = null;
        XElement item = null;

        reader.MoveToContent();

        // Parse the file, save header information when encountered, and yield the
        // Item XElement objects as they are created.

        // loop through Customer elements
        while (reader.Read())
        {
            if (reader.NodeType == XmlNodeType.Element
                && reader.Name == "Customer")
            {
                // move to Name element
                while (reader.Read())
                {
                    if (reader.NodeType == XmlNodeType.Element &&
                        reader.Name == "Name")
                    {
                        name = XElement.ReadFrom(reader) as XElement;
                        break;
                    }
                }

                // loop through Item elements
                while (reader.Read())
                {
                    if (reader.NodeType == XmlNodeType.EndElement)
                        break;
                    if (reader.NodeType == XmlNodeType.Element
                        && reader.Name == "Item")
                    {
                        item = XElement.ReadFrom(reader) as XElement;
                        if (item != null)
                        {
                            XElement tempRoot = new XElement("Root",
                                new XElement(name)
                            );
                            tempRoot.Add(item);
                            yield return item;
                        }
                    }
                }
            }
        }
    }
}

static void Main(string[] args)
{
    XStreamingElement root = new XStreamingElement("Root",
        from el in StreamCustomerItem("Source.xml")
        select new XElement("Item",
            new XElement("Customer", (string)el.Parent.Element("Name")),
            new XElement(el.Element("Key"))
        )
    );
    root.Save("Test.xml");
    Console.WriteLine(File.ReadAllText("Test.xml"));
}
```

This code produces the following output:

```
<?xml version="1.0" encoding="utf-8"?>
<Root>
  <Item>
    <Customer>A. Datum Corporation</Customer>
    <Key>0001</Key>
  </Item>
  <Item>
    <Customer>A. Datum Corporation</Customer>
    <Key>0002</Key>
  </Item>
  <Item>
    <Customer>A. Datum Corporation</Customer>
    <Key>0003</Key>
  </Item>
  <Item>
    <Customer>A. Datum Corporation</Customer>
    <Key>0004</Key>
  </Item>
  <Item>
    <Customer>Fabrikam, Inc.</Customer>
    <Key>0005</Key>
  </Item>
  <Item>
    <Customer>Fabrikam, Inc.</Customer>
    <Key>0006</Key>
  </Item>
  <Item>
    <Customer>Fabrikam, Inc.</Customer>
    <Key>0007</Key>
  </Item>
  <Item>
    <Customer>Fabrikam, Inc.</Customer>
    <Key>0008</Key>
  </Item>
  <Item>
    <Customer>Southridge Video</Customer>
    <Key>0009</Key>
  </Item>
  <Item>
    <Customer>Southridge Video</Customer>
    <Key>0010</Key>
  </Item>
</Root>
```

Example

The following example also builds on the example in How to: Stream XML Fragments with Access to Header Information (C#).

This example uses the capability of LINQ to XML to write elements to an XmlWriter. This example can transform a very large document while maintaining a small memory footprint.

Note that the custom axis (`StreamCustomerItem`) is specifically written so that it expects a document that has `Customer`, `Name`, and `Item` elements, and that those elements will be arranged as in the following Source.xml document. A more robust implementation, however, would either validate the source document with an XSD, or would be prepared to parse an invalid document.

This example uses the same source document, Source.xml, as the previous example in this topic. It also produces exactly the same output.

Using XStreamingElement for streaming the output XML is preferred over writing to an XmlWriter.

```
static IEnumerable<XElement> StreamCustomerItem(string uri)
{
    using (XmlReader reader = XmlReader.Create(uri))
    {
        XElement name = null;
        XElement item = null;

        reader.MoveToContent();

        // Parse the file, save header information when encountered, and yield the
        // Item XElement objects as they are created.

        // loop through Customer elements
        while (reader.Read())
        {
            if (reader.NodeType == XmlNodeType.Element
                && reader.Name == "Customer")
            {
                // move to Name element
                while (reader.Read())
                {
                    if (reader.NodeType == XmlNodeType.Element &&
                        reader.Name == "Name")
                    {
                        name = XElement.ReadFrom(reader) as XElement;
                        break;
                    }
                }

                // loop through Item elements
                while (reader.Read())
                {
                    if (reader.NodeType == XmlNodeType.EndElement)
                        break;
                    if (reader.NodeType == XmlNodeType.Element
                        && reader.Name == "Item")
                    {
                        item = XElement.ReadFrom(reader) as XElement;
                        if (item != null) {
                            XElement tempRoot = new XElement("Root",
                                new XElement(name)
                            );
                            tempRoot.Add(item);
                            yield return item;
                        }
                    }
                }
            }
        }
    }
}

static void Main(string[] args)
{
    IEnumerable<XElement> srcTree =
        from el in StreamCustomerItem("Source.xml")
        select new XElement("Item",
            new XElement("Customer", (string)el.Parent.Element("Name")),
            new XElement(el.Element("Key"))
        );
    XmlWriterSettings xws = new XmlWriterSettings();
    xws.OmitXmlDeclaration = true;
    xws.Indent = true;
    using (XmlWriter xw = XmlWriter.Create("Output.xml", xws)) {
        xw.WriteStartElement("Root");
        foreach (XElement el in srcTree)
            el.WriteTo(xw);
        xw.WriteEndElement();
    }

    string str = File.ReadAllText("Output.xml");
    Console.WriteLine(str);
}
```

This code produces the following output:

```
<Root>
  <Item>
    <Customer>A. Datum Corporation</Customer>
    <Key>0001</Key>
  </Item>
  <Item>
    <Customer>A. Datum Corporation</Customer>
    <Key>0002</Key>
  </Item>
  <Item>
    <Customer>A. Datum Corporation</Customer>
    <Key>0003</Key>
  </Item>
  <Item>
    <Customer>A. Datum Corporation</Customer>
    <Key>0004</Key>
  </Item>
  <Item>
    <Customer>Fabrikam, Inc.</Customer>
    <Key>0005</Key>
  </Item>
  <Item>
    <Customer>Fabrikam, Inc.</Customer>
    <Key>0006</Key>
  </Item>
  <Item>
    <Customer>Fabrikam, Inc.</Customer>
    <Key>0007</Key>
  </Item>
  <Item>
    <Customer>Fabrikam, Inc.</Customer>
    <Key>0008</Key>
  </Item>
  <Item>
    <Customer>Southridge Video</Customer>
    <Key>0009</Key>
  </Item>
  <Item>
    <Customer>Southridge Video</Customer>
    <Key>0010</Key>
  </Item>
</Root>
```

See also

- Advanced LINQ to XML Programming (C#)

How to: Read and Write an Encoded Document (C#)

1/23/2019 • 2 minutes to read • Edit Online

To create an encoded XML document, you add an XDeclaration to the XML tree, setting the encoding to the desired code page name.

Any value returned by WebName is a valid value.

If you read an encoded document, the Encoding property will be set to the code page name.

If you set Encoding to a valid code page name, LINQ to XML will serialize with the specified encoding.

Example

The following example creates two documents, one with utf-8 encoding, and one with utf-16 encoding. It then loads the documents and prints the encoding to the console.

```
Console.WriteLine("Creating a document with utf-8 encoding");
XDocument encodedDoc8 = new XDocument(
    new XDeclaration("1.0", "utf-8", "yes"),
    new XElement("Root", "Content")
);
encodedDoc8.Save("EncodedUtf8.xml");
Console.WriteLine("Encoding is:{0}", encodedDoc8.Declaration.Encoding);
Console.WriteLine();

Console.WriteLine("Creating a document with utf-16 encoding");
XDocument encodedDoc16 = new XDocument(
    new XDeclaration("1.0", "utf-16", "yes"),
    new XElement("Root", "Content")
);
encodedDoc16.Save("EncodedUtf16.xml");
Console.WriteLine("Encoding is:{0}", encodedDoc16.Declaration.Encoding);
Console.WriteLine();

XDocument newDoc8 = XDocument.Load("EncodedUtf8.xml");
Console.WriteLine("Encoded document:");
Console.WriteLine(File.ReadAllText("EncodedUtf8.xml"));
Console.WriteLine();
Console.WriteLine("Encoding of loaded document is:{0}", newDoc8.Declaration.Encoding);
Console.WriteLine();

XDocument newDoc16 = XDocument.Load("EncodedUtf16.xml");
Console.WriteLine("Encoded document:");
Console.WriteLine(File.ReadAllText("EncodedUtf16.xml"));
Console.WriteLine();
Console.WriteLine("Encoding of loaded document is:{0}", newDoc16.Declaration.Encoding);
```

This example produces the following output:

```
Creating a document with utf-8 encoding
Encoding is:utf-8

Creating a document with utf-16 encoding
Encoding is:utf-16

Encoded document:
<?xml version="1.0" encoding="utf-8" standalone="yes"?>
<Root>Content</Root>

Encoding of loaded document is:utf-8

Encoded document:
<?xml version="1.0" encoding="utf-16" standalone="yes"?>
<Root>Content</Root>

Encoding of loaded document is:utf-16
```

See also

- XDeclaration.Encoding
- Advanced LINQ to XML Programming (C#)

Using XSLT to Transform an XML Tree (C#)

1/23/2019 • 2 minutes to read • Edit Online

You can create an XML tree, create an XmlReader from the XML tree, create a new document, and create an XmlWriter that will write into the new document. Then, you can invoke the XSLT transformation, passing the XmlReader and XmlWriter to the transformation. After the transformation successfully completes, the new XML tree is populated with the results of the transform.

Example

```
string xslMarkup = @"<?xml version='1.0'?>
<xsl:stylesheet xmlns:xsl='http://www.w3.org/1999/XSL/Transform' version='1.0'>
    <xsl:template match='/Parent'>
        <Root>
            <C1>
            <xsl:value-of select='Child1'/>
            </C1>
            <C2>
            <xsl:value-of select='Child2'/>
            </C2>
        </Root>
    </xsl:template>
</xsl:stylesheet>";

XDocument xmlTree = new XDocument(
    new XElement("Parent",
        new XElement("Child1", "Child1 data"),
        new XElement("Child2", "Child2 data")
    )
);

XDocument newTree = new XDocument();
using (XmlWriter writer = newTree.CreateWriter()) {
    // Load the style sheet.
    XslCompiledTransform xslt = new XslCompiledTransform();
    xslt.Load(XmlReader.Create(new StringReader(xslMarkup)));

    // Execute the transform and output the results to a writer.
    xslt.Transform(xmlTree.CreateReader(), writer);
}

Console.WriteLine(newTree);
```

This example produces the following output:

```
<Root>
  <C1>Child1 data</C1>
  <C2>Child2 data</C2>
</Root>
```

See also

- XContainer.CreateWriter
- XNode.CreateReader
- Advanced LINQ to XML Programming (C#)

How to: Use Annotations to Transform LINQ to XML Trees in an XSLT Style (C#)

1/23/2019 • 7 minutes to read • Edit Online

Annotations can be used to facilitate transforms of an XML tree.

Some XML documents are "document centric with mixed content." With such documents, you don't necessarily know the shape of child nodes of an element. For instance, a node that contains text may look like this:

```
<text>A phrase with <b>bold</b> and <i>italic</i> text.</text>
```

For any given text node, there may be any number of child `<b>` and `<i>` elements. This approach extends to a number of other situations, such as pages that can contain a variety of child elements, such as regular paragraphs, bulleted paragraphs, and bitmaps. Cells in a table may contain text, drop down lists, or bitmaps. One of the primary characteristics of document centric XML is that you do not know which child element any particular element will have.

If you want to transform elements in a tree where you don't necessarily know much about the children of the elements that you want to transform, then this approach that uses annotations is an effective approach.

The summary of the approach is:

- First, annotate elements in the tree with a replacement element.
- Second, iterate through the entire tree, creating a new tree where you replace each element with its annotation. This example implements the iteration and creation of the new tree in a function named `XForm`.

In detail, the approach consists of:

- Execute one or more LINQ to XML queries that return the set of elements that you want to transform from one shape to another. For each element in the query, add a new XElement object as an annotation to the element. This new element will replace the annotated element in the new, transformed tree. This is simple code to write, as demonstrated by the example.
- The new element that is added as an annotation can contain new child nodes; it can form a sub-tree with any desired shape.
- There is a special rule: If a child node of the new element is in a different namespace, a namespace that is made up for this purpose (in this example, the namespace is `http://www.microsoft.com/LinqToXmlTransform/2007`), then that child element is not copied to the new tree. Instead, if the namespace is the above mentioned special namespace, and the local name of the element is `ApplyTransforms`, then the child nodes of the element in the source tree are iterated, and copied to the new tree (with the exception that annotated child elements are themselves transformed according to these rules).
- This is somewhat analogous to the specification of transforms in XSL. The query that selects a set of nodes is analogous to the XPath expression for a template. The code to create the new XElement that is saved as an annotation is analogous to the sequence constructor in XSL, and the `ApplyTransforms` element is analogous in function to the `xsl:apply-templates` element in XSL.
- One advantage to taking this approach - as you formulate queries, you are always writing queries on the unmodified source tree. You need not worry about how modifications to the tree affect the queries that you are writing.

Transforming a Tree

This first example renames all `Paragraph` nodes to `para`.

```
XNamespace xf = "http://www.microsoft.com/LinqToXmlTransform/2007";
XName at = xf + "ApplyTransforms";

XElement root = XElement.Parse(@"
<Root>
    <Paragraph>This is a sentence with <b>bold</b> and <i>italic</i> text.</Paragraph>
    <Paragraph>More text.</Paragraph>
</Root>");

// replace Paragraph with para
foreach (var el in root.Descendants("Paragraph"))
    el.AddAnnotation(
        new XElement("para",
            // same idea as xsl:apply-templates
            new XElement(xf + "ApplyTransforms")
        )
    );

// The XForm method, shown later in this topic, accomplishes the transform
XElement newRoot = XForm(root);

Console.WriteLine(newRoot);
```

This example produces the following output:

```
<Root>
  <para>This is a sentence with <b>bold</b> and <i>italic</i> text.</para>
  <para>More text.</para>
</Root>
```

A More Complicated Transform

The following example queries the tree and calculates the average and sum of the `Data` elements, and adds them as new elements to the tree.

```
XNamespace xf = "http://www.microsoft.com/LinqToXmlTransform/2007";
XName at = xf + "ApplyTransforms";

XElement data = new XElement("Root",
    new XElement("Data", 20),
    new XElement("Data", 10),
    new XElement("Data", 3)
);

// while adding annotations, you can query the source tree all you want,
// as the tree is not mutated while annotating.
var avg = data.Elements("Data").Select(z => (Decimal)z).Average();
data.AddAnnotation(
    new XElement("Root",
        new XElement(xf + "ApplyTransforms"),
        new XElement("Average", $"{avg:F4}"),
        new XElement("Sum",
            data
            .Elements("Data")
            .Select(z => (int)z)
            .Sum()
        )
    )
);

Console.WriteLine("Before Transform");
Console.WriteLine("----------------");
Console.WriteLine(data);
Console.WriteLine();
Console.WriteLine();

// The XForm method, shown later in this topic, accomplishes the transform
XElement newData = XForm(data);

Console.WriteLine("After Transform");
Console.WriteLine("----------------");
Console.WriteLine(newData);
```

This example produces the following output:

```
Before Transform
----------------
<Root>
  <Data>20</Data>
  <Data>10</Data>
  <Data>3</Data>
</Root>

After Transform
----------------
<Root>
  <Data>20</Data>
  <Data>10</Data>
  <Data>3</Data>
  <Average>11.0000</Average>
  <Sum>33</Sum>
</Root>
```

Effecting the Transform

A small function, `XForm`, creates a new transformed tree from the original, annotated tree.

- The pseudo code for the function is quite simple:

```
The function takes an XElement as an argument and returns an XElement.
If an element has an XElement annotation, then
    Return a new XElement
        The name of the new XElement is the annotation element's name.
        All attributes are copied from the annotation to the new node.
        All child nodes are copied from the annotation, with the
            exception that the special node xf:ApplyTransforms is
            recognized, and the source element's child nodes are
            iterated. If the source child node is not an XElement, it
            is copied to the new tree. If the source child is an
            XElement, then it is transformed by calling this function
            recursively.
If an element is not annotated
    Return a new XElement
        The name of the new XElement is the source element's name
        All attributes are copied from the source element to the
            destination's element.
        All child nodes are copied from the source element.
        If the source child node is not an XElement, it is copied to
            the new tree. If the source child is an XElement, then it
            is transformed by calling this function recursively.
```

Following is the implementation of this function:

```
// Build a transformed XML tree per the annotations
static XElement XForm(XElement source)
{
    XNamespace xf = "http://www.microsoft.com/LinqToXmlTransform/2007";
    XName at = xf + "ApplyTransforms";

    if (source.Annotation<XElement>() != null)
    {
        XElement anno = source.Annotation<XElement>();
        return new XElement(anno.Name,
            anno.Attributes(),
            anno
            .Nodes()
            .Select(
                (XNode n) =>
                {
                    XElement annoEl = n as XElement;
                    if (annoEl != null)
                    {
                        if (annoEl.Name == at)
                            return (object)(
                                source.Nodes()
                                .Select(
                                    (XNode n2) =>
                                    {
                                        XElement e2 = n2 as XElement;
                                        if (e2 == null)
                                            return n2;
                                        else
                                            return XForm(e2);
                                    }
                                )
                            );
                        else
                            return n;
                    }
                    else
                        return n;
                }
            )
        );
    }
    else
    {
        return new XElement(source.Name,
            source.Attributes(),
            source
                .Nodes()
                .Select(n =>
                {
                    XElement el = n as XElement;
                    if (el == null)
                        return n;
                    else
                        return XForm(el);
                }
                )
        );
    }
}
```

Complete Example

The following code is a complete example that includes the `XForm` function. It includes a few of the typical uses of this type of transform:

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Xml;
using System.Xml.Linq;

class Program
{
    static XNamespace xf = "http://www.microsoft.com/LinqToXmlTransform/2007";
    static XName at = xf + "ApplyTransforms";

    // Build a transformed XML tree per the annotations
    static XElement XForm(XElement source)
    {
        if (source.Annotation<XElement>() != null)
        {
            XElement anno = source.Annotation<XElement>();
            return new XElement(anno.Name,
                anno.Attributes(),
                anno
                .Nodes()
                .Select(
                    (XNode n) =>
                    {
                        XElement annoEl = n as XElement;
                        if (annoEl != null)
                        {
                            if (annoEl.Name == at)
                                return (object)(
                                    source.Nodes()
                                    .Select(
                                        (XNode n2) =>
                                        {
                                            XElement e2 = n2 as XElement;
                                            if (e2 == null)
                                                return n2;
                                            else
                                                return XForm(e2);
                                        }
                                    )
                                );
                            else
                                return n;
                        }
                        else
                            return n;
                    }
                )
            );
        }
        else
        {
            return new XElement(source.Name,
                source.Attributes(),
                source
                    .Nodes()
                    .Select(n =>
                    {
                        XElement el = n as XElement;
                        if (el == null)
                            return n;
                        else
                            return XForm(el);
                    }
                    )
            );
        }
    }

    static void Main(string[] args)
    {
        XElement root = new XElement("Root",
            new XComment("A comment"),
            new XAttribute("Att1", 123),
            new XElement("Child", 1),
            new XElement("Child", 2),
            new XElement("Other",
                new XElement("GC", 3),
                new XElement("GC", 4)
            ),
            XElement.Parse(
              "<SomeMixedContent>This is <i>an</i> element that " +
              "<b>has</b> some mixed content</SomeMixedContent>"),
            new XElement("AnUnchangedElement", 42)
        );

        // each of the following serves the same semantic purpose as
        // XSLT templates and sequence constructors

        // replace Child with NewChild
        foreach (var el in root.Elements("Child"))
            el.AddAnnotation(new XElement("NewChild", (string)el));

        // replace first GC with GrandChild, add an attribute
        foreach (var el in root.Descendants("GC").Take(1))
            el.AddAnnotation(
                new XElement("GrandChild",
                    new XAttribute("ANewAttribute", 999),
                    (string)el
                )
            );

        // replace Other with NewOther, add new child elements around original content
        foreach (var el in root.Elements("Other"))
            el.AddAnnotation(
                new XElement("NewOther",
                    new XElement("MyNewChild", 1),
                    // same idea as xsl:apply-templates
                    new XElement(xf + "ApplyTransforms"),
                    new XElement("ChildThatComesAfter")
                )
            );

        // change name of element that has mixed content
        root.Descendants("SomeMixedContent").First().AddAnnotation(
            new XElement("MixedContent",
                new XElement(xf + "ApplyTransforms")
            )
        );

        // replace <b> with <Bold>
        foreach (var el in root.Descendants("b"))
            el.AddAnnotation(
                new XElement("Bold",
                    new XElement(xf + "ApplyTransforms")
                )
            );

        // replace <i> with <Italic>
        foreach (var el in root.Descendants("i"))
            el.AddAnnotation(
                new XElement("Italic",
                    new XElement(xf + "ApplyTransforms")
                )
            );
        Console.WriteLine("Before Transform");
        Console.WriteLine("----------------");
        Console.WriteLine(root);
        Console.WriteLine();
        Console.WriteLine();
        XElement newRoot = XForm(root);

        Console.WriteLine("After Transform");
        Console.WriteLine("----------------");
        Console.WriteLine(newRoot);
    }
}
```

This example produces the following output:

```
Before Transform
----------------
<Root Att1="123">
  <!--A comment-->
  <Child>1</Child>
  <Child>2</Child>
  <Other>
    <GC>3</GC>
    <GC>4</GC>
  </Other>
  <SomeMixedContent>This is <i>an</i> element that <b>has</b> some mixed content</SomeMixedContent>
  <AnUnchangedElement>42</AnUnchangedElement>
</Root>

After Transform
----------------
<Root Att1="123">
  <!--A comment-->
  <NewChild>1</NewChild>
  <NewChild>2</NewChild>
  <NewOther>
    <MyNewChild>1</MyNewChild>
    <GrandChild ANewAttribute="999">3</GrandChild>
    <GC>4</GC>
    <ChildThatComesAfter />
  </NewOther>
  <MixedContent>This is <Italic>an</Italic> element that <Bold>has</Bold> some mixed content</MixedContent>
  <AnUnchangedElement>42</AnUnchangedElement>
</Root>
```

See also

- Advanced LINQ to XML Programming (C#)

Serializing Object Graphs that Contain XElement Objects (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic introduces the capability of serializing object graphs that contain references to objects of type XElement. To facility this type of serializing, XElement implements the IXmlSerializable interface.

Note that only the XElement class implements serialization.

In This Section

TOPIC	DESCRIPTION
How to: Serialize Using XmlSerializer (C#)	Demonstrates how to serialize using XmlSerializer.
How to: Serialize Using DataContractSerializer (C#)	Demonstrates how to serialize using DataContractSerializer.

See also

- Advanced LINQ to XML Programming (C#)

How to: Serialize Using XmlSerializer (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows an example that serializes and deserializes using XmlSerializer.

Example

The following example creates a number of objects that contain XElement objects. It then serializes them to a memory stream, and then deserializes them from the memory stream.

```
using System;
using System.IO;
using System.Linq;
using System.Xml;
using System.Xml.Serialization;
using System.Xml.Linq;

public class XElementContainer
{
    public XElement member;

    public XElementContainer()
    {
        member = XLinqTest.CreateXElement();
    }

    public override string ToString()
    {
        return member.ToString();
    }
}

public class XElementNullContainer
{
    public XElement member;

    public XElementNullContainer()
    {
    }
}

class XLinqTest
{
    static void Main(string[] args)
    {
        Test<XElementNullContainer>(new XElementNullContainer());
        Test<XElement>(CreateXElement());
        Test<XElementContainer>(new XElementContainer());
    }

    public static XElement CreateXElement()
    {
        XNamespace ns = "http://www.adventure-works.com";
        return new XElement(ns + "aw");
    }

    static void Test<T>(T obj)
    {
        using (MemoryStream stream = new MemoryStream())
        {
            XmlSerializer s = new XmlSerializer(typeof(T));
            Console.WriteLine("Testing for type: {0}", typeof(T));
            s.Serialize(XmlWriter.Create(stream), obj);
            stream.Flush();
            stream.Seek(0, SeekOrigin.Begin);
            object o = s.Deserialize(XmlReader.Create(stream));
            Console.WriteLine("  Deserialized type: {0}", o.GetType());
        }
    }
}
```

This example produces the following output:

```
Testing for type: XElementNullContainer
  Deserialized type: XElementNullContainer
Testing for type: System.Xml.Linq.XElement
  Deserialized type: System.Xml.Linq.XElement
Testing for type: XElementContainer
  Deserialized type: XElementContainer
```

See also

- Serializing Object Graphs that Contain XElement Objects (C#)

How to: Serialize Using DataContractSerializer (C#)

1/23/2019 • 2 minutes to read • Edit Online

This topic shows an example that serializes and deserializes using DataContractSerializer.

Example

The following example creates a number of objects that contain XElement objects. It then serializes them to text files, and then deserializes them from the text files.

```
using System;
using System.Xml;
using System.Xml.Linq;
using System.IO;
using System.Runtime.Serialization;

public class XLinqTest
{
    public static void Main()
    {
        Test<XElement>(CreateXElement());
        Test<XElementContainer>(new XElementContainer());
        Test<XElementNullContainer>(new XElementNullContainer());
    }

    public static void Test<T>(T obj)
    {
        DataContractSerializer s = new DataContractSerializer(typeof(T));
        using (FileStream fs = File.Open("test" + typeof(T).Name + ".xml", FileMode.Create))
        {
            Console.WriteLine("Testing for type: {0}", typeof(T));
            s.WriteObject(fs, obj);
        }
        using (FileStream fs = File.Open("test" + typeof(T).Name + ".xml", FileMode.Open))
        {
            object s2 = s.ReadObject(fs);
            if (s2 == null)
                Console.WriteLine("  Deserialized object is null (Nothing in VB)");
            else
                Console.WriteLine("  Deserialized type: {0}", s2.GetType());
        }
    }

    public static XElement CreateXElement()
    {
        return new XElement(XName.Get("NameInNamespace", "http://www.adventure-works.org"));
    }
}

[DataContract]
public class XElementContainer
{
    [DataMember]
    public XElement member;

    public XElementContainer()
    {
        member = XLinqTest.CreateXElement();
    }
}

[DataContract]
public class XElementNullContainer
{
    [DataMember]
    public XElement member;

    public XElementNullContainer()
    {
        member = null;
    }
}
```

This example produces the following output:

```
Testing for type: System.Xml.Linq.XElement
  Deserialized type: System.Xml.Linq.XElement
Testing for type: XElementContainer
  Deserialized type: XElementContainer
Testing for type: XElementNullContainer
  Deserialized type: XElementNullContainer
```

See also

- Serializing Object Graphs that Contain XElement Objects (C#)

LINQ to XML Security (C#)

1/23/2019 • 7 minutes to read • Edit Online

This topic describes security issues associated with LINQ to XML. In addition, it provides some guidance for mitigating security exposure.

LINQ to XML Security Overview

LINQ to XML is designed more for programming convenience than for server-side applications with stringent security requirements. Most XML scenarios consist of processing trusted XML documents, rather than processing untrusted XML documents that are uploaded to a server. LINQ to XML is optimized for these scenarios.

If you must process untrusted data from unknown sources, Microsoft recommends that you use an instance of the XmlReader class that has been configured to filter out known XML denial of service (DoS) attacks.

If you have configured an XmlReader to mitigate denial of service attacks, you can use that reader to populate a LINQ to XML tree and still benefit from the programmer productivity enhancements of LINQ to XML. Many mitigation techniques involve creating readers that are configured to mitigate the security issue, and then instantiating an XML tree through the configured reader.

XML is intrinsically vulnerable to denial of service attacks because documents are unbounded in size, depth, element name size, and more. Regardless of the component that you use to process XML, you should always be prepared to recycle the application domain if it uses excessive resources.

Mitigation of XML, XSD, XPath, and XSLT Attacks

LINQ to XML is built upon XmlReader and XmlWriter. LINQ to XML supports XSD and XPath through extension methods in the System.Xml.Schema and System.Xml.XPath namespaces. Using the XmlReader, XPathNavigator, and XmlWriter classes in conjunction with LINQ to XML, you can invoke XSLT to transform XML trees.

If you are operating in a less secure environment, there are a number of security issues that are associated with XML and the use of the classes in System.Xml, System.Xml.Schema, System.Xml.XPath, and System.Xml.Xsl. These issues include, but are not limited to, the following:

- XSD, XPath, and XSLT are string-based languages in which you can specify operations that consume a lot of time or memory. It is the responsibility of application programmers who take XSD, XPath, or XSLT strings from untrusted sources to validate that the strings are not malicious, or to monitor and mitigate the possibility that evaluating these strings will lead to excessive system resource consumption.
- XSD schemas (including inline schemas) are inherently vulnerable to denial of service attacks; you should not accept schemas from untrusted sources.
- XSD and XSLT can include references to other files, and such references can result in cross-zone and cross-domain attacks.
- External entities in DTDs can result in cross-zone and cross-domain attacks.
- DTDs are vulnerable to denial of service attacks.
- Exceptionally deep XML documents can pose denial of service issues; you might want to limit the depth of XML documents.
- Do not accept supporting components, such as NameTable, XmlNamespaceManager, and XmlResolver objects, from untrusted assemblies.

- Read data in chunks to mitigate large document attacks.
- Script blocks in XSLT style sheets can expose a number of attacks.
- Validate carefully before constructing dynamic XPath expressions.

LINQ to XML Security Issues

The security issues in this topic are not presented in any particular order. All issues are important and should be addressed as appropriate.

A successful elevation of privilege attack gives a malicious assembly more control over its environment. A successful elevation of privilege attack can result in disclosure of data, denial of service, and more.

Applications should not disclose data to users who are not authorized to see that data.

Denial of service attacks cause the XML parser or LINQ to XML to consume excessive amounts of memory or CPU time. Denial of service attacks are considered to be less severe than elevation of privilege attacks or disclosure of data attacks. However, they are important in a scenario where a server needs to process XML documents from untrusted sources.

Exceptions and Error Messages Might Reveal Data

The description of an error might reveal data, such as the data being transformed, file names, or implementation details. Error messages should not be exposed to callers that are not trusted. You should catch all errors and report errors with your own custom error messages.

Do Not Call CodeAccessPermissions.Assert in an Event Handler

An assembly can have lesser or greater permissions. An assembly that has greater permissions has greater control over the computer and its environments.

If code in an assembly with greater permissions calls CodeAccessPermission.Assert in an event handler, and then the XML tree is passed to a malicious assembly that has restricted permissions, the malicious assembly can cause an event to be raised. Because the event runs code that is in the assembly with greater permissions, the malicious assembly would then be operating with elevated privileges.

Microsoft recommends that you never call CodeAccessPermission.Assert in an event handler.

DTDs are Not Secure

Entities in DTDs are inherently not secure. It is possible for a malicious XML document that contains a DTD to cause the parser to use all memory and CPU time, causing a denial of service attack. Therefore, in LINQ to XML, DTD processing is turned off by default. You should not accept DTDs from untrusted sources.

One example of accepting DTDs from untrusted sources is a Web application that allows Web users to upload an XML file that references a DTD and a DTD file. Upon validation of the file, a malicious DTD could execute a denial of service attack on your server. Another example of accepting DTDs from untrusted sources is to reference a DTD on a network share that also allows anonymous FTP access.

Avoid Excessive Buffer Allocation

Application developers should be aware that extremely large data sources can lead to resource exhaustion and denial of service attacks.

If a malicious user submits or uploads a very large XML document, it could cause LINQ to XML to consume excessive system resources. This can constitute a denial of service attack. To prevent this, you can set the XmlReaderSettings.MaxCharactersInDocument property, and create a reader that is then limited in the size of document that it can load. You then use the reader to create the XML tree.

For example, if you know that the maximum expected size of your XML documents coming from an untrusted source will be less than 50K bytes, set XmlReaderSettings.MaxCharactersInDocument to 100,000. This will not encumber your processing of XML documents, and at the same time it will mitigate denial of service threats where documents might be uploaded that would consume large amounts of memory.

Avoid Excess Entity Expansion

One of the known denial of service attacks when using a DTD is a document that causes excessive entity expansion. To prevent this, you can set the XmlReaderSettings.MaxCharactersFromEntities property, and create a reader that is then limited in the number of characters that result from entity expansion. You then use the reader to create the XML tree.

Limit the Depth of the XML Hierarchy

One possible denial of service attack is when a document is submitted that has excessive depth of hierarchy. To prevent this, you can wrap a XmlReader in your own class that counts the depth of elements. If the depth exceeds a predetermined reasonable level, you can terminate the processing of the malicious document.

Protect Against Untrusted XmlReader or XmlWriter Implementations

Administrators should verify that any externally supplied XmlReader or XmlWriter implementations have strong names and have been registered in the machine configuration. This prevents malicious code masquerading as a reader or writer from being loaded.

Periodically Free Objects that Reference XName

To protect against certain kinds of attacks, application programmers should free all objects that reference an XName object in the application domain on a regular basis.

Protect Against Random XML Names

Applications that take data from untrusted sources should consider using an XmlReader that is wrapped in custom code to inspect for the possibility of random XML names and namespaces. If such random XML names and namespaces are detected, the application can then terminate the processing of the malicious document.

You might want to limit the number of names in any given namespace (including names in no namespace) to a reasonable limit.

Annotations Are Accessible by Software Components that Share a LINQ to XML Tree

LINQ to XML could be used to build processing pipelines in which different application components load, validate, query, transform, update, and save XML data that is passed between components as XML trees. This can help optimize performance, because the overhead of loading and serializing objects to XML text is done only at the ends of the pipeline. Developers must be aware, however, that all annotations and event handlers created by one component are accessible to other components. This can create a number of vulnerabilities if the components have different levels of trust. To build secure pipelines across less trusted components, you must serialize LINQ to XML objects to XML text before passing the data to an untrusted component.

Some security is provided by the common language runtime (CLR). For example, a component that does not include a private class cannot access annotations keyed by that class. However, annotations can be deleted by components that cannot read them. This could be used as a tampering attack.

See also

- Programming Guide (LINQ to XML) (C#)

Sample XML Documents (LINQ to XML)

1/23/2019 • 2 minutes to read • Edit Online

The following example files are used in the code samples and code snippets throughout the LINQ to XML documentation.

NOTE

The example companies, organizations, products, domain names, e-mail addresses, logos, people, places, and events depicted herein are fictitious. No association with any real company, organization, product, domain name, e-mail address, logo, person, places, or events is intended or should be inferred.

In This Section

TOPIC	DESCRIPTION
Sample XML File: Typical Purchase Order (LINQ to XML)	An XML document that contains a typical purchase order.
Sample XML File: Typical Purchase Order in a Namespace	An XML document in a namespace that contains a typical purchase order.
Sample XML File: Multiple Purchase Orders (LINQ to XML)	An XML document that contains multiple purchase orders.
Sample XML File: Multiple Purchase Orders in a Namespace	An XML document in a namespace that contains multiple purchase orders.
Sample XML File: Test Configuration (LINQ to XML)	An XML document that contains some pseudo test configuration data.
Sample XML File: Test Configuration in a Namespace	An XML document in a namespace that contains some pseudo test configuration data.
Sample XML File: Customers and Orders (LINQ to XML)	An XML document that contains customers and orders.
Sample XSD File: Customers and Orders	An Xml Schema Definition (XSD) that validates the Sample XML File: Customers and Orders (LINQ to XML).
Sample XML File: Customers and Orders in a Namespace	An XML document in a namespace that contains customers and orders.
Sample XML File: Numerical Data (LINQ to XML)	An XML document that contains data suitable for summing and grouping.
Sample XML File: Numerical Data in a Namespace	An XML document in a namespace that contains data suitable for summing and grouping.
Sample XML File: Books (LINQ to XML)	An XML document that contains a catalog of books.
Sample XML File: Consolidated Purchase Orders	Presents an XML document that contains purchase orders that are in different namespaces.

See also

- Programming Guide (LINQ to XML) (C#)

Sample XML File: Typical Purchase Order (LINQ to XML)

1/23/2019 • 2 minutes to read • Edit Online

The following XML file is used in various examples in the LINQ to XML documentation. This file is a typical purchase order.

PurchaseOrder.xml

```
<?xml version="1.0"?>
<PurchaseOrder PurchaseOrderNumber="99503" OrderDate="1999-10-20">
  <Address Type="Shipping">
    <Name>Ellen Adams</Name>
    <Street>123 Maple Street</Street>
    <City>Mill Valley</City>
    <State>CA</State>
    <Zip>10999</Zip>
    <Country>USA</Country>
  </Address>
  <Address Type="Billing">
    <Name>Tai Yee</Name>
    <Street>8 Oak Avenue</Street>
    <City>Old Town</City>
    <State>PA</State>
    <Zip>95819</Zip>
    <Country>USA</Country>
  </Address>
  <DeliveryNotes>Please leave packages in shed by driveway.</DeliveryNotes>
  <Items>
    <Item PartNumber="872-AA">
      <ProductName>Lawnmower</ProductName>
      <Quantity>1</Quantity>
      <USPrice>148.95</USPrice>
      <Comment>Confirm this is electric</Comment>
    </Item>
    <Item PartNumber="926-AA">
      <ProductName>Baby Monitor</ProductName>
      <Quantity>2</Quantity>
      <USPrice>39.98</USPrice>
      <ShipDate>1999-05-21</ShipDate>
    </Item>
  </Items>
</PurchaseOrder>
```

See also

- Sample XML Documents (LINQ to XML)

Sample XML File: Typical Purchase Order in a Namespace

1/23/2019 • 2 minutes to read • Edit Online

The following XML file is used in various examples in the LINQ to XML documentation. This file is a typical purchase order. The XML is in a namespace.

PurchaseOrderInNamespace.xml

```
<?xml version="1.0"?>
<aw:PurchaseOrder
    aw:PurchaseOrderNumber="99503"
    aw:OrderDate="1999-10-20"
    xmlns:aw="http://www.adventure-works.com">
  <aw:Address aw:Type="Shipping">
    <aw:Name>Ellen Adams</aw:Name>
    <aw:Street>123 Maple Street</aw:Street>
    <aw:City>Mill Valley</aw:City>
    <aw:State>CA</aw:State>
    <aw:Zip>10999</aw:Zip>
    <aw:Country>USA</aw:Country>
  </aw:Address>
  <aw:Address aw:Type="Billing">
    <aw:Name>Tai Yee</aw:Name>
    <aw:Street>8 Oak Avenue</aw:Street>
    <aw:City>Old Town</aw:City>
    <aw:State>PA</aw:State>
    <aw:Zip>95819</aw:Zip>
    <aw:Country>USA</aw:Country>
  </aw:Address>
  <aw:DeliveryNotes>Please leave packages in shed by driveway.</aw:DeliveryNotes>
  <aw:Items>
    <aw:Item aw:PartNumber="872-AA">
      <aw:ProductName>Lawnmower</aw:ProductName>
      <aw:Quantity>1</aw:Quantity>
      <aw:USPrice>148.95</aw:USPrice>
      <aw:Comment>Confirm this is electric</aw:Comment>
    </aw:Item>
    <aw:Item aw:PartNumber="926-AA">
      <aw:ProductName>Baby Monitor</aw:ProductName>
      <aw:Quantity>2</aw:Quantity>
      <aw:USPrice>39.98</aw:USPrice>
      <aw:ShipDate>1999-05-21</aw:ShipDate>
    </aw:Item>
  </aw:Items>
</aw:PurchaseOrder>
```

See also

- Sample XML Documents (LINQ to XML)

Sample XML File: Multiple Purchase Orders (LINQ to XML)

1/23/2019 • 2 minutes to read • Edit Online

The following XML file is used in various examples in the LINQ to XML documentation. This file contains several purchase orders.

PurchaseOrders.xml

```xml
<?xml version="1.0"?>
<PurchaseOrders>
  <PurchaseOrder PurchaseOrderNumber="99503" OrderDate="1999-10-20">
    <Address Type="Shipping">
      <Name>Ellen Adams</Name>
      <Street>123 Maple Street</Street>
      <City>Mill Valley</City>
      <State>CA</State>
      <Zip>10999</Zip>
      <Country>USA</Country>
    </Address>
    <Address Type="Billing">
      <Name>Tai Yee</Name>
      <Street>8 Oak Avenue</Street>
      <City>Old Town</City>
      <State>PA</State>
      <Zip>95819</Zip>
      <Country>USA</Country>
    </Address>
    <DeliveryNotes>Please leave packages in shed by driveway.</DeliveryNotes>
    <Items>
      <Item PartNumber="872-AA">
        <ProductName>Lawnmower</ProductName>
        <Quantity>1</Quantity>
        <USPrice>148.95</USPrice>
        <Comment>Confirm this is electric</Comment>
      </Item>
      <Item PartNumber="926-AA">
        <ProductName>Baby Monitor</ProductName>
        <Quantity>2</Quantity>
        <USPrice>39.98</USPrice>
        <ShipDate>1999-05-21</ShipDate>
      </Item>
    </Items>
  </PurchaseOrder>
  <PurchaseOrder PurchaseOrderNumber="99505" OrderDate="1999-10-22">
    <Address Type="Shipping">
      <Name>Cristian Osorio</Name>
      <Street>456 Main Street</Street>
      <City>Buffalo</City>
      <State>NY</State>
      <Zip>98112</Zip>
      <Country>USA</Country>
    </Address>
    <Address Type="Billing">
      <Name>Cristian Osorio</Name>
      <Street>456 Main Street</Street>
      <City>Buffalo</City>
      <State>NY</State>
      <Zip>98112</Zip>
      <Country>USA</Country>
      <Country>USA</Country>
    </Address>
    <DeliveryNotes>Please notify me before shipping.</DeliveryNotes>
    <Items>
      <Item PartNumber="456-NM">
        <ProductName>Power Supply</ProductName>
        <Quantity>1</Quantity>
        <USPrice>45.99</USPrice>
      </Item>
    </Items>
  </PurchaseOrder>
  <PurchaseOrder PurchaseOrderNumber="99504" OrderDate="1999-10-22">
    <Address Type="Shipping">
      <Name>Jessica Arnold</Name>
      <Street>4055 Madison Ave</Street>
      <City>Seattle</City>
      <State>WA</State>
      <Zip>98112</Zip>
      <Country>USA</Country>
    </Address>
    <Address Type="Billing">
      <Name>Jessica Arnold</Name>
      <Street>4055 Madison Ave</Street>
      <City>Buffalo</City>
      <State>NY</State>
      <Zip>98112</Zip>
      <Country>USA</Country>
    </Address>
    <Items>
      <Item PartNumber="898-AZ">
        <ProductName>Computer Keyboard</ProductName>
        <Quantity>1</Quantity>
        <USPrice>29.99</USPrice>
      </Item>
      <Item PartNumber="898-AM">
        <ProductName>Wireless Mouse</ProductName>
        <Quantity>1</Quantity>
        <USPrice>14.99</USPrice>
      </Item>
    </Items>
  </PurchaseOrder>
</PurchaseOrders>
```

See also

- Sample XML Documents (LINQ to XML)

Sample XML File: Multiple Purchase Orders in a Namespace

1/23/2019 • 2 minutes to read • Edit Online

The following XML file is used in various examples in the LINQ to XML documentation. This file contains several purchase orders. The XML is in a namespace.

PurchaseOrdersInNamespace.xml

```xml
<?xml version="1.0" encoding="utf-8"?>
<aw:PurchaseOrders xmlns:aw="http://www.adventure-works.com">
  <aw:PurchaseOrder aw:PurchaseOrderNumber="99503" aw:OrderDate="1999-10-20">
    <aw:Address aw:Type="Shipping">
      <aw:Name>Ellen Adams</aw:Name>
      <aw:Street>123 Maple Street</aw:Street>
      <aw:City>Mill Valley</aw:City>
      <aw:State>CA</aw:State>
      <aw:Zip>10999</aw:Zip>
      <aw:Country>USA</aw:Country>
    </aw:Address>
    <aw:Address aw:Type="Billing">
      <aw:Name>Tai Yee</aw:Name>
      <aw:Street>8 Oak Avenue</aw:Street>
      <aw:City>Old Town</aw:City>
      <aw:State>PA</aw:State>
      <aw:Zip>95819</aw:Zip>
      <aw:Country>USA</aw:Country>
    </aw:Address>
    <aw:DeliveryNotes>Please leave packages in shed by driveway.</aw:DeliveryNotes>
    <aw:Items>
      <aw:Item aw:PartNumber="872-AA">
        <aw:ProductName>Lawnmower</aw:ProductName>
        <aw:Quantity>1</aw:Quantity>
        <aw:USPrice>148.95</aw:USPrice>
        <aw:Comment>Confirm this is electric</aw:Comment>
      </aw:Item>
      <aw:Item aw:PartNumber="926-AA">
        <aw:ProductName>Baby Monitor</aw:ProductName>
        <aw:Quantity>2</aw:Quantity>
        <aw:USPrice>39.98</aw:USPrice>
        <aw:ShipDate>1999-05-21</aw:ShipDate>
      </aw:Item>
    </aw:Items>
  </aw:PurchaseOrder>
  <aw:PurchaseOrder aw:PurchaseOrderNumber="99505" aw:OrderDate="1999-10-22">
    <aw:Address aw:Type="Shipping">
      <aw:Name>Cristian Osorio</aw:Name>
      <aw:Street>456 Main Street</aw:Street>
      <aw:City>Buffalo</aw:City>
      <aw:State>NY</aw:State>
      <aw:Zip>98112</aw:Zip>
      <aw:Country>USA</aw:Country>
    </aw:Address>
    <aw:Address aw:Type="Billing">
      <aw:Name>Cristian Osorio</aw:Name>
      <aw:Street>456 Main Street</aw:Street>
      <aw:City>Buffalo</aw:City>
      <aw:State>NY</aw:State>
      <aw:Zip>98112</aw:Zip>
      <aw:Country>USA</aw:Country>
      <aw:Country>USA</aw:Country>
    </aw:Address>
    <aw:DeliveryNotes>Please notify me before shipping.</aw:DeliveryNotes>
    <aw:Items>
      <aw:Item aw:PartNumber="456-NM">
        <aw:ProductName>Power Supply</aw:ProductName>
        <aw:Quantity>1</aw:Quantity>
        <aw:USPrice>45.99</aw:USPrice>
      </aw:Item>
    </aw:Items>
  </aw:PurchaseOrder>
  <aw:PurchaseOrder aw:PurchaseOrderNumber="99504" aw:OrderDate="1999-10-22">
    <aw:Address aw:Type="Shipping">
      <aw:Name>Jessica Arnold</aw:Name>
      <aw:Street>4055 Madison Ave</aw:Street>
      <aw:City>Seattle</aw:City>
      <aw:State>WA</aw:State>
      <aw:Zip>98112</aw:Zip>
      <aw:Country>USA</aw:Country>
    </aw:Address>
    <aw:Address aw:Type="Billing">
      <aw:Name>Jessica Arnold</aw:Name>
      <aw:Street>4055 Madison Ave</aw:Street>
      <aw:City>Buffalo</aw:City>
      <aw:State>NY</aw:State>
      <aw:Zip>98112</aw:Zip>
      <aw:Country>USA</aw:Country>
    </aw:Address>
    <aw:Items>
      <aw:Item aw:PartNumber="898-AZ">
        <aw:ProductName>Computer Keyboard</aw:ProductName>
        <aw:Quantity>1</aw:Quantity>
        <aw:USPrice>29.99</aw:USPrice>
      </aw:Item>
      <aw:Item aw:PartNumber="898-AM">
        <aw:ProductName>Wireless Mouse</aw:ProductName>
        <aw:Quantity>1</aw:Quantity>
        <aw:USPrice>14.99</aw:USPrice>
      </aw:Item>
    </aw:Items>
  </aw:PurchaseOrder>
</aw:PurchaseOrders>
```

See also

- Sample XML Documents (LINQ to XML)

Sample XML File: Test Configuration (LINQ to XML)

1/23/2019 • 2 minutes to read • Edit Online

The following XML file is used in various examples in the LINQ to XML documentation. This is a test configuration file.

TestConfig.xml

```
<?xml version="1.0"?>
<Tests>
  <Test TestId="0001" TestType="CMD">
    <Name>Convert number to string</Name>
    <CommandLine>Examp1.EXE</CommandLine>
    <Input>1</Input>
    <Output>One</Output>
  </Test>
  <Test TestId="0002" TestType="CMD">
    <Name>Find succeeding characters</Name>
    <CommandLine>Examp2.EXE</CommandLine>
    <Input>abc</Input>
    <Output>def</Output>
  </Test>
  <Test TestId="0003" TestType="GUI">
    <Name>Convert multiple numbers to strings</Name>
    <CommandLine>Examp2.EXE /Verbose</CommandLine>
    <Input>123</Input>
    <Output>One Two Three</Output>
  </Test>
  <Test TestId="0004" TestType="GUI">
    <Name>Find correlated key</Name>
    <CommandLine>Examp3.EXE</CommandLine>
    <Input>a1</Input>
    <Output>b1</Output>
  </Test>
  <Test TestId="0005" TestType="GUI">
    <Name>Count characters</Name>
    <CommandLine>FinalExamp.EXE</CommandLine>
    <Input>This is a test</Input>
    <Output>14</Output>
  </Test>
  <Test TestId="0006" TestType="GUI">
    <Name>Another Test</Name>
    <CommandLine>Examp2.EXE</CommandLine>
    <Input>Test Input</Input>
    <Output>10</Output>
  </Test>
</Tests>
```

See also

- Sample XML Documents (LINQ to XML)

Sample XML File: Test Configuration in a Namespace

1/23/2019 • 2 minutes to read • Edit Online

The following XML file is used in various examples in the LINQ to XML documentation. This is a test configuration file. The XML is in a namespace.

TestConfigInNamespace.xml

```xml
<?xml version="1.0"?>
<Tests xmlns="http://www.adatum.com">
  <Test TestId="0001" TestType="CMD">
    <Name>Convert number to string</Name>
    <CommandLine>Examp1.EXE</CommandLine>
    <Input>1</Input>
    <Output>One</Output>
  </Test>
  <Test TestId="0002" TestType="CMD">
    <Name>Find succeeding characters</Name>
    <CommandLine>Examp2.EXE</CommandLine>
    <Input>abc</Input>
    <Output>def</Output>
  </Test>
  <Test TestId="0003" TestType="GUI">
    <Name>Convert multiple numbers to strings</Name>
    <CommandLine>Examp2.EXE /Verbose</CommandLine>
    <Input>123</Input>
    <Output>One Two Three</Output>
  </Test>
  <Test TestId="0004" TestType="GUI">
    <Name>Find correlated key</Name>
    <CommandLine>Examp3.EXE</CommandLine>
    <Input>a1</Input>
    <Output>b1</Output>
  </Test>
  <Test TestId="0005" TestType="GUI">
    <Name>Count characters</Name>
    <CommandLine>FinalExamp.EXE</CommandLine>
    <Input>This is a test</Input>
    <Output>14</Output>
  </Test>
  <Test TestId="0006" TestType="GUI">
    <Name>Another Test</Name>
    <CommandLine>Examp2.EXE</CommandLine>
    <Input>Test Input</Input>
    <Output>10</Output>
  </Test>
</Tests>
```

See also

- Sample XML Documents (LINQ to XML)

Sample XML File: Customers and Orders (LINQ to XML)

1/23/2019 • 3 minutes to read • Edit Online

The following XML file is used in various examples in the LINQ to XML documentation. This file contains customers and orders.

The topic Sample XSD File: Customers and Orders contains an XSD that can be used to validate this document. It uses the `xs:key` and `xs:keyref` features of XSD to establish that the `CustomerID` attribute of the `Customer` element is a key, and to establish a relationship between the `CustomerID` element in each `Order` element and the `CustomerID` attribute in each `Customer` element.

For an example of writing LINQ queries that take advantage of this relationship using the `Join` clause, see How to: Join Two Collections (LINQ to XML) (C#).

CustomersOrders.xml

```
<?xml version="1.0" encoding="utf-8"?>
<Root>
  <Customers>
    <Customer CustomerID="GREAL">
      <CompanyName>Great Lakes Food Market</CompanyName>
      <ContactName>Howard Snyder</ContactName>
      <ContactTitle>Marketing Manager</ContactTitle>
      <Phone>(503) 555-7555</Phone>
      <FullAddress>
        <Address>2732 Baker Blvd.</Address>
        <City>Eugene</City>
        <Region>OR</Region>
        <PostalCode>97403</PostalCode>
        <Country>USA</Country>
      </FullAddress>
    </Customer>
    <Customer CustomerID="HUNGC">
      <CompanyName>Hungry Coyote Import Store</CompanyName>
      <ContactName>Yoshi Latimer</ContactName>
      <ContactTitle>Sales Representative</ContactTitle>
      <Phone>(503) 555-6874</Phone>
      <Fax>(503) 555-2376</Fax>
      <FullAddress>
        <Address>City Center Plaza 516 Main St.</Address>
        <City>Elgin</City>
        <Region>OR</Region>
        <PostalCode>97827</PostalCode>
        <Country>USA</Country>
      </FullAddress>
    </Customer>
    <Customer CustomerID="LAZYK">
      <CompanyName>Lazy K Kountry Store</CompanyName>
      <ContactName>John Steel</ContactName>
      <ContactTitle>Marketing Manager</ContactTitle>
      <Phone>(509) 555-7969</Phone>
      <Fax>(509) 555-6221</Fax>
      <FullAddress>
        <Address>12 Orchestra Terrace</Address>
        <City>Walla Walla</City>
        <Region>WA</Region>
        <PostalCode>99362</PostalCode>
        <Country>USA</Country>
      </FullAddress>
    </Customer>
    <Customer CustomerID="LETSS">
      <CompanyName>Let's Stop N Shop</CompanyName>
      <ContactName>Jaime Yorres</ContactName>
      <ContactTitle>Owner</ContactTitle>
      <Phone>(415) 555-5938</Phone>
      <FullAddress>
        <Address>87 Polk St. Suite 5</Address>
        <City>San Francisco</City>
        <Region>CA</Region>
        <PostalCode>94117</PostalCode>
        <Country>USA</Country>
      </FullAddress>
    </Customer>
  </Customers>
  <Orders>
    <Order>
      <CustomerID>GREAL</CustomerID>
      <EmployeeID>6</EmployeeID>
      <OrderDate>1997-05-06T00:00:00</OrderDate>
      <RequiredDate>1997-05-20T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-05-09T00:00:00">
        <ShipVia>2</ShipVia>
        <Freight>3.35</Freight>
        <ShipName>Great Lakes Food Market</ShipName>
        <ShipAddress>2732 Baker Blvd.</ShipAddress>
        <ShipCity>Eugene</ShipCity>
        <ShipRegion>OR</ShipRegion>
        <ShipPostalCode>97403</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>GREAL</CustomerID>
      <EmployeeID>8</EmployeeID>
      <OrderDate>1997-07-04T00:00:00</OrderDate>
      <RequiredDate>1997-08-01T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-07-14T00:00:00">
        <ShipVia>2</ShipVia>
        <Freight>4.42</Freight>
        <ShipName>Great Lakes Food Market</ShipName>
        <ShipAddress>2732 Baker Blvd.</ShipAddress>
        <ShipCity>Eugene</ShipCity>
        <ShipRegion>OR</ShipRegion>
        <ShipPostalCode>97403</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>GREAL</CustomerID>
      <EmployeeID>1</EmployeeID>
      <OrderDate>1997-07-31T00:00:00</OrderDate>
      <RequiredDate>1997-08-28T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-08-05T00:00:00">
        <ShipVia>2</ShipVia>
        <Freight>116.53</Freight>
        <ShipName>Great Lakes Food Market</ShipName>
        <ShipAddress>2732 Baker Blvd.</ShipAddress>
        <ShipCity>Eugene</ShipCity>
        <ShipRegion>OR</ShipRegion>
        <ShipPostalCode>97403</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>GREAL</CustomerID>
      <EmployeeID>4</EmployeeID>
```

```xml
        <OrderDate>1997-07-31T00:00:00</OrderDate>
        <RequiredDate>1997-08-28T00:00:00</RequiredDate>
        <ShipInfo ShippedDate="1997-08-04T00:00:00">
          <ShipVia>2</ShipVia>
          <Freight>18.53</Freight>
          <ShipName>Great Lakes Food Market</ShipName>
          <ShipAddress>2732 Baker Blvd.</ShipAddress>
          <ShipCity>Eugene</ShipCity>
          <ShipRegion>OR</ShipRegion>
          <ShipPostalCode>97403</ShipPostalCode>
          <ShipCountry>USA</ShipCountry>
        </ShipInfo>
      </Order>
      <Order>
        <CustomerID>GREAL</CustomerID>
        <EmployeeID>6</EmployeeID>
        <OrderDate>1997-09-04T00:00:00</OrderDate>
        <RequiredDate>1997-10-02T00:00:00</RequiredDate>
        <ShipInfo ShippedDate="1997-09-10T00:00:00">
          <ShipVia>1</ShipVia>
          <Freight>57.15</Freight>
          <ShipName>Great Lakes Food Market</ShipName>
          <ShipAddress>2732 Baker Blvd.</ShipAddress>
          <ShipCity>Eugene</ShipCity>
          <ShipRegion>OR</ShipRegion>
          <ShipPostalCode>97403</ShipPostalCode>
          <ShipCountry>USA</ShipCountry>
        </ShipInfo>
      </Order>
      <Order>
        <CustomerID>GREAL</CustomerID>
        <EmployeeID>3</EmployeeID>
        <OrderDate>1997-09-25T00:00:00</OrderDate>
        <RequiredDate>1997-10-23T00:00:00</RequiredDate>
        <ShipInfo ShippedDate="1997-09-30T00:00:00">
          <ShipVia>3</ShipVia>
          <Freight>76.13</Freight>
          <ShipName>Great Lakes Food Market</ShipName>
          <ShipAddress>2732 Baker Blvd.</ShipAddress>
          <ShipCity>Eugene</ShipCity>
          <ShipRegion>OR</ShipRegion>
          <ShipPostalCode>97403</ShipPostalCode>
          <ShipCountry>USA</ShipCountry>
        </ShipInfo>
      </Order>
      <Order>
        <CustomerID>GREAL</CustomerID>
        <EmployeeID>4</EmployeeID>
        <OrderDate>1998-01-06T00:00:00</OrderDate>
        <RequiredDate>1998-02-03T00:00:00</RequiredDate>
        <ShipInfo ShippedDate="1998-02-04T00:00:00">
          <ShipVia>2</ShipVia>
          <Freight>719.78</Freight>
          <ShipName>Great Lakes Food Market</ShipName>
          <ShipAddress>2732 Baker Blvd.</ShipAddress>
          <ShipCity>Eugene</ShipCity>
          <ShipRegion>OR</ShipRegion>
          <ShipPostalCode>97403</ShipPostalCode>
          <ShipCountry>USA</ShipCountry>
        </ShipInfo>
      </Order>
      <Order>
        <CustomerID>GREAL</CustomerID>
        <EmployeeID>3</EmployeeID>
        <OrderDate>1998-03-09T00:00:00</OrderDate>
        <RequiredDate>1998-04-06T00:00:00</RequiredDate>
        <ShipInfo ShippedDate="1998-03-18T00:00:00">
          <ShipVia>2</ShipVia>
          <Freight>33.68</Freight>
      <Freight>59.88</Freight>
      <ShipName>Great Lakes Food Market</ShipName>
      <ShipAddress>2732 Baker Blvd.</ShipAddress>
      <ShipCity>Eugene</ShipCity>
      <ShipRegion>OR</ShipRegion>
      <ShipPostalCode>97403</ShipPostalCode>
      <ShipCountry>USA</ShipCountry>
    </ShipInfo>
  </Order>
  <Order>
    <CustomerID>GREAL</CustomerID>
    <EmployeeID>3</EmployeeID>
    <OrderDate>1998-04-07T00:00:00</OrderDate>
    <RequiredDate>1998-05-05T00:00:00</RequiredDate>
    <ShipInfo ShippedDate="1998-04-15T00:00:00">
      <ShipVia>2</ShipVia>
      <Freight>25.19</Freight>
      <ShipName>Great Lakes Food Market</ShipName>
      <ShipAddress>2732 Baker Blvd.</ShipAddress>
      <ShipCity>Eugene</ShipCity>
      <ShipRegion>OR</ShipRegion>
      <ShipPostalCode>97403</ShipPostalCode>
      <ShipCountry>USA</ShipCountry>
    </ShipInfo>
  </Order>
  <Order>
    <CustomerID>GREAL</CustomerID>
    <EmployeeID>4</EmployeeID>
    <OrderDate>1998-04-22T00:00:00</OrderDate>
    <RequiredDate>1998-05-20T00:00:00</RequiredDate>
    <ShipInfo>
      <ShipVia>3</ShipVia>
      <Freight>18.84</Freight>
      <ShipName>Great Lakes Food Market</ShipName>
      <ShipAddress>2732 Baker Blvd.</ShipAddress>
      <ShipCity>Eugene</ShipCity>
      <ShipRegion>OR</ShipRegion>
      <ShipPostalCode>97403</ShipPostalCode>
      <ShipCountry>USA</ShipCountry>
    </ShipInfo>
  </Order>
  <Order>
    <CustomerID>GREAL</CustomerID>
    <EmployeeID>4</EmployeeID>
    <OrderDate>1998-04-30T00:00:00</OrderDate>
    <RequiredDate>1998-06-11T00:00:00</RequiredDate>
    <ShipInfo>
      <ShipVia>3</ShipVia>
      <Freight>14.01</Freight>
      <ShipName>Great Lakes Food Market</ShipName>
      <ShipAddress>2732 Baker Blvd.</ShipAddress>
      <ShipCity>Eugene</ShipCity>
      <ShipRegion>OR</ShipRegion>
      <ShipPostalCode>97403</ShipPostalCode>
      <ShipCountry>USA</ShipCountry>
    </ShipInfo>
  </Order>
  <Order>
    <CustomerID>HUNGC</CustomerID>
    <EmployeeID>3</EmployeeID>
    <OrderDate>1996-12-06T00:00:00</OrderDate>
    <RequiredDate>1997-01-03T00:00:00</RequiredDate>
    <ShipInfo ShippedDate="1996-12-09T00:00:00">
      <ShipVia>2</ShipVia>
      <Freight>20.12</Freight>
      <ShipName>Hungry Coyote Import Store</ShipName>
      <ShipAddress>City Center Plaza 516 Main St.</ShipAddress>
      <ShipCity>Elgin</ShipCity>
      <ShipRegion>OR</ShipRegion>
      <ShipPostalCode>97827</ShipPostalCode>
```

```
        <ShipPostalCode>97827</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>HUNGC</CustomerID>
      <EmployeeID>1</EmployeeID>
      <OrderDate>1996-12-25T00:00:00</OrderDate>
      <RequiredDate>1997-01-22T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-01-03T00:00:00">
        <ShipVia>3</ShipVia>
        <Freight>30.34</Freight>
        <ShipName>Hungry Coyote Import Store</ShipName>
        <ShipAddress>City Center Plaza 516 Main St.</ShipAddress>
        <ShipCity>Elgin</ShipCity>
        <ShipRegion>OR</ShipRegion>
        <ShipPostalCode>97827</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>HUNGC</CustomerID>
      <EmployeeID>3</EmployeeID>
      <OrderDate>1997-01-15T00:00:00</OrderDate>
      <RequiredDate>1997-02-12T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-01-24T00:00:00">
        <ShipVia>1</ShipVia>
        <Freight>0.2</Freight>
        <ShipName>Hungry Coyote Import Store</ShipName>
        <ShipAddress>City Center Plaza 516 Main St.</ShipAddress>
        <ShipCity>Elgin</ShipCity>
        <ShipRegion>OR</ShipRegion>
        <ShipPostalCode>97827</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>HUNGC</CustomerID>
      <EmployeeID>4</EmployeeID>
      <OrderDate>1997-07-16T00:00:00</OrderDate>
      <RequiredDate>1997-08-13T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-07-21T00:00:00">
        <ShipVia>1</ShipVia>
        <Freight>45.13</Freight>
        <ShipName>Hungry Coyote Import Store</ShipName>
        <ShipAddress>City Center Plaza 516 Main St.</ShipAddress>
        <ShipCity>Elgin</ShipCity>
        <ShipRegion>OR</ShipRegion>
        <ShipPostalCode>97827</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>HUNGC</CustomerID>
      <EmployeeID>8</EmployeeID>
      <OrderDate>1997-09-08T00:00:00</OrderDate>
      <RequiredDate>1997-10-06T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-10-15T00:00:00">
        <ShipVia>1</ShipVia>
        <Freight>111.29</Freight>
        <ShipName>Hungry Coyote Import Store</ShipName>
        <ShipAddress>City Center Plaza 516 Main St.</ShipAddress>
        <ShipCity>Elgin</ShipCity>
        <ShipRegion>OR</ShipRegion>
        <ShipPostalCode>97827</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
```

```
      <CustomerID>LAZYK</CustomerID>
      <EmployeeID>1</EmployeeID>
      <OrderDate>1997-03-21T00:00:00</OrderDate>
      <RequiredDate>1997-04-18T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-04-10T00:00:00">
        <ShipVia>3</ShipVia>
        <Freight>7.48</Freight>
        <ShipName>Lazy K Kountry Store</ShipName>
        <ShipAddress>12 Orchestra Terrace</ShipAddress>
        <ShipCity>Walla Walla</ShipCity>
        <ShipRegion>WA</ShipRegion>
        <ShipPostalCode>99362</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>LAZYK</CustomerID>
      <EmployeeID>8</EmployeeID>
      <OrderDate>1997-05-22T00:00:00</OrderDate>
      <RequiredDate>1997-06-19T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-06-26T00:00:00">
        <ShipVia>2</ShipVia>
        <Freight>11.92</Freight>
        <ShipName>Lazy K Kountry Store</ShipName>
        <ShipAddress>12 Orchestra Terrace</ShipAddress>
        <ShipCity>Walla Walla</ShipCity>
        <ShipRegion>WA</ShipRegion>
        <ShipPostalCode>99362</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>LETSS</CustomerID>
      <EmployeeID>1</EmployeeID>
      <OrderDate>1997-06-25T00:00:00</OrderDate>
      <RequiredDate>1997-07-23T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-07-04T00:00:00">
        <ShipVia>2</ShipVia>
        <Freight>13.73</Freight>
        <ShipName>Let's Stop N Shop</ShipName>
        <ShipAddress>87 Polk St. Suite 5</ShipAddress>
        <ShipCity>San Francisco</ShipCity>
        <ShipRegion>CA</ShipRegion>
        <ShipPostalCode>94117</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>LETSS</CustomerID>
      <EmployeeID>8</EmployeeID>
      <OrderDate>1997-10-27T00:00:00</OrderDate>
      <RequiredDate>1997-11-24T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-11-05T00:00:00">
        <ShipVia>2</ShipVia>
        <Freight>51.44</Freight>
        <ShipName>Let's Stop N Shop</ShipName>
        <ShipAddress>87 Polk St. Suite 5</ShipAddress>
        <ShipCity>San Francisco</ShipCity>
        <ShipRegion>CA</ShipRegion>
        <ShipPostalCode>94117</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>LETSS</CustomerID>
      <EmployeeID>6</EmployeeID>
      <OrderDate>1997-11-10T00:00:00</OrderDate>
      <RequiredDate>1997-12-08T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-11-21T00:00:00">
```

```
        <ShipVia>2</ShipVia>
        <Freight>45.97</Freight>
        <ShipName>Let's Stop N Shop</ShipName>
        <ShipAddress>87 Polk St. Suite 5</ShipAddress>
        <ShipCity>San Francisco</ShipCity>
        <ShipRegion>CA</ShipRegion>
        <ShipPostalCode>94117</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>LETSS</CustomerID>
      <EmployeeID>4</EmployeeID>
      <OrderDate>1998-02-12T00:00:00</OrderDate>
      <RequiredDate>1998-03-12T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1998-02-13T00:00:00">
        <ShipVia>2</ShipVia>
        <Freight>90.97</Freight>
        <ShipName>Let's Stop N Shop</ShipName>
        <ShipAddress>87 Polk St. Suite 5</ShipAddress>
        <ShipCity>San Francisco</ShipCity>
        <ShipRegion>CA</ShipRegion>
        <ShipPostalCode>94117</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
  </Orders>
</Root>
```

See also

- Sample XML Documents (LINQ to XML)

Sample XSD File: Customers and Orders

1/23/2019 • 2 minutes to read • Edit Online

The following XSD file is used in various examples in the LINQ to XML documentation. This file contains a schema definition for the Sample XML File: Customers and Orders (LINQ to XML). The schema uses the `xs:key` and `xs:keyref` features of XSD to establish that the `CustomerID` attribute of the `Customer` element is a key, and to establish a relationship between the `CustomerID` element in each `Order` element and the `CustomerID` attribute in each `Customer` element.

For an example of writing LINQ queries that take advantage of this relationship using the `Join` clause, see How to: Join Two Collections (LINQ to XML) (C#).

CustomersOrders.xsd

```
<?xml version="1.0" encoding="utf-8" ?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema">
  <xs:element name='Root'>
    <xs:complexType>
      <xs:sequence>
        <xs:element name='Customers'>
          <xs:complexType>
            <xs:sequence>
              <xs:element name='Customer' type='CustomerType' minOccurs='0' maxOccurs='unbounded' />
            </xs:sequence>
          </xs:complexType>
        </xs:element>
        <xs:element name='Orders'>
          <xs:complexType>
            <xs:sequence>
              <xs:element name='Order' type='OrderType' minOccurs='0' maxOccurs='unbounded' />
            </xs:sequence>
          </xs:complexType>
        </xs:element>
      </xs:sequence>
    </xs:complexType>
    <xs:key name='CustomerIDKey'>
      <xs:selector xpath='Customers/Customer'/>
      <xs:field xpath='@CustomerID'/>
    </xs:key>
    <xs:keyref name='CustomerIDKeyRef' refer='CustomerIDKey'>
      <xs:selector xpath='Orders/Order'/>
      <xs:field xpath='CustomerID'/>
    </xs:keyref>
  </xs:element>
  <xs:complexType name='CustomerType'>
    <xs:sequence>
      <xs:element name='CompanyName' type='xs:string'/>
      <xs:element name='ContactName' type='xs:string'/>
      <xs:element name='ContactTitle' type='xs:string'/>
      <xs:element name='Phone' type='xs:string'/>
      <xs:element name='Fax' minOccurs='0' type='xs:string'/>
      <xs:element name='FullAddress' type='AddressType'/>
    </xs:sequence>
    <xs:attribute name='CustomerID' type='xs:token'/>
  </xs:complexType>
  <xs:complexType name='AddressType'>
    <xs:sequence>
      <xs:element name='Address' type='xs:string'/>
      <xs:element name='City' type='xs:string'/>
      <xs:element name='Region' type='xs:string'/>
      <xs:element name='PostalCode' type='xs:string' />
      <xs:element name='Country' type='xs:string'/>
    </xs:sequence>
    <xs:attribute name='CustomerID' type='xs:token'/>
  </xs:complexType>
  <xs:complexType name='OrderType'>
    <xs:sequence>
      <xs:element name='CustomerID' type='xs:token'/>
      <xs:element name='EmployeeID' type='xs:token'/>
      <xs:element name='OrderDate' type='xs:dateTime'/>
      <xs:element name='RequiredDate' type='xs:dateTime'/>
      <xs:element name='ShipInfo' type='ShipInfoType'/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name='ShipInfoType'>
    <xs:sequence>
      <xs:element name='ShipVia' type='xs:integer'/>
      <xs:element name='Freight' type='xs:decimal'/>
      <xs:element name='ShipName' type='xs:string'/>
      <xs:element name='ShipAddress' type='xs:string'/>
      <xs:element name='ShipCity' type='xs:string'/>
      <xs:element name='ShipRegion' type='xs:string'/>
      <xs:element name='ShipPostalCode' type='xs:string'/>
      <xs:element name='ShipCountry' type='xs:string'/>
    </xs:sequence>
    <xs:attribute name='ShippedDate' type='xs:dateTime'/>
  </xs:complexType>
</xs:schema>
```

See also

- Sample XML Documents (LINQ to XML)

Sample XML File: Customers and Orders in a Namespace

1/23/2019 • 3 minutes to read • Edit Online

The following XML file is used in various examples in the LINQ to XML documentation. This file contains customers and orders. The XML is in a namespace.

CustomersOrdersInNamespace.xml

```xml
<?xml version="1.0" encoding="utf-8"?>
<Root xmlns="http://www.adventure-works.com">
  <Customers>
    <Customer CustomerID="GREAL">
      <CompanyName>Great Lakes Food Market</CompanyName>
      <ContactName>Howard Snyder</ContactName>
      <ContactTitle>Marketing Manager</ContactTitle>
      <Phone>(503) 555-7555</Phone>
      <FullAddress>
        <Address>2732 Baker Blvd.</Address>
        <City>Eugene</City>
        <Region>OR</Region>
        <PostalCode>97403</PostalCode>
        <Country>USA</Country>
      </FullAddress>
    </Customer>
    <Customer CustomerID="HUNGC">
      <CompanyName>Hungry Coyote Import Store</CompanyName>
      <ContactName>Yoshi Latimer</ContactName>
      <ContactTitle>Sales Representative</ContactTitle>
      <Phone>(503) 555-6874</Phone>
      <Fax>(503) 555-2376</Fax>
      <FullAddress>
        <Address>City Center Plaza 516 Main St.</Address>
        <City>Elgin</City>
        <Region>OR</Region>
        <PostalCode>97827</PostalCode>
        <Country>USA</Country>
      </FullAddress>
    </Customer>
    <Customer CustomerID="LAZYK">
      <CompanyName>Lazy K Kountry Store</CompanyName>
      <ContactName>John Steel</ContactName>
      <ContactTitle>Marketing Manager</ContactTitle>
      <Phone>(509) 555-7969</Phone>
      <Fax>(509) 555-6221</Fax>
      <FullAddress>
        <Address>12 Orchestra Terrace</Address>
        <City>Walla Walla</City>
        <Region>WA</Region>
        <PostalCode>99362</PostalCode>
        <Country>USA</Country>
      </FullAddress>
    </Customer>
    <Customer CustomerID="LETSS">
      <CompanyName>Let's Stop N Shop</CompanyName>
      <ContactName>Jaime Yorres</ContactName>
      <ContactTitle>Owner</ContactTitle>
      <Phone>(415) 555-5938</Phone>
      <FullAddress>
        <Address>87 Polk St. Suite 5</Address>
```

```
          <Address>87 Polk St. Suite 5</Address>
          <City>San Francisco</City>
          <Region>CA</Region>
          <PostalCode>94117</PostalCode>
          <Country>USA</Country>
        </FullAddress>
      </Customer>
    </Customers>
    <Orders>
      <Order>
        <CustomerID>GREAL</CustomerID>
        <EmployeeID>6</EmployeeID>
        <OrderDate>1997-05-06T00:00:00</OrderDate>
        <RequiredDate>1997-05-20T00:00:00</RequiredDate>
        <ShipInfo ShippedDate="1997-05-09T00:00:00">
          <ShipVia>2</ShipVia>
          <Freight>3.35</Freight>
          <ShipName>Great Lakes Food Market</ShipName>
          <ShipAddress>2732 Baker Blvd.</ShipAddress>
          <ShipCity>Eugene</ShipCity>
          <ShipRegion>OR</ShipRegion>
          <ShipPostalCode>97403</ShipPostalCode>
          <ShipCountry>USA</ShipCountry>
        </ShipInfo>
      </Order>
      <Order>
        <CustomerID>GREAL</CustomerID>
        <EmployeeID>8</EmployeeID>
        <OrderDate>1997-07-04T00:00:00</OrderDate>
        <RequiredDate>1997-08-01T00:00:00</RequiredDate>
        <ShipInfo ShippedDate="1997-07-14T00:00:00">
          <ShipVia>2</ShipVia>
          <Freight>4.42</Freight>
          <ShipName>Great Lakes Food Market</ShipName>
          <ShipAddress>2732 Baker Blvd.</ShipAddress>
          <ShipCity>Eugene</ShipCity>
          <ShipRegion>OR</ShipRegion>
          <ShipPostalCode>97403</ShipPostalCode>
          <ShipCountry>USA</ShipCountry>
        </ShipInfo>
      </Order>
      <Order>
        <CustomerID>GREAL</CustomerID>
        <EmployeeID>1</EmployeeID>
        <OrderDate>1997-07-31T00:00:00</OrderDate>
        <RequiredDate>1997-08-28T00:00:00</RequiredDate>
        <ShipInfo ShippedDate="1997-08-05T00:00:00">
          <ShipVia>2</ShipVia>
          <Freight>116.53</Freight>
          <ShipName>Great Lakes Food Market</ShipName>
          <ShipAddress>2732 Baker Blvd.</ShipAddress>
          <ShipCity>Eugene</ShipCity>
          <ShipRegion>OR</ShipRegion>
          <ShipPostalCode>97403</ShipPostalCode>
          <ShipCountry>USA</ShipCountry>
        </ShipInfo>
      </Order>
      <Order>
        <CustomerID>GREAL</CustomerID>
        <EmployeeID>4</EmployeeID>
        <OrderDate>1997-07-31T00:00:00</OrderDate>
        <RequiredDate>1997-08-28T00:00:00</RequiredDate>
        <ShipInfo ShippedDate="1997-08-04T00:00:00">
          <ShipVia>2</ShipVia>
          <Freight>18.53</Freight>
          <ShipName>Great Lakes Food Market</ShipName>
          <ShipAddress>2732 Baker Blvd.</ShipAddress>
          <ShipCity>Eugene</ShipCity>
          <ShipRegion>OR</ShipRegion>
          <ShipPostalCode>97403</ShipPostalCode>
          <ShipCountry>USA</ShipCountry>
        </ShipInfo>
      </Order>
      <Order>
        <CustomerID>GREAL</CustomerID>
        <EmployeeID>6</EmployeeID>
        <OrderDate>1997-09-04T00:00:00</OrderDate>
        <RequiredDate>1997-10-02T00:00:00</RequiredDate>
        <ShipInfo ShippedDate="1997-09-10T00:00:00">
          <ShipVia>1</ShipVia>
          <Freight>57.15</Freight>
          <ShipName>Great Lakes Food Market</ShipName>
          <ShipAddress>2732 Baker Blvd.</ShipAddress>
          <ShipCity>Eugene</ShipCity>
          <ShipRegion>OR</ShipRegion>
          <ShipPostalCode>97403</ShipPostalCode>
          <ShipCountry>USA</ShipCountry>
        </ShipInfo>
      </Order>
      <Order>
        <CustomerID>GREAL</CustomerID>
        <EmployeeID>3</EmployeeID>
        <OrderDate>1997-09-25T00:00:00</OrderDate>
        <RequiredDate>1997-10-23T00:00:00</RequiredDate>
        <ShipInfo ShippedDate="1997-09-30T00:00:00">
          <ShipVia>3</ShipVia>
          <Freight>76.13</Freight>
          <ShipName>Great Lakes Food Market</ShipName>
          <ShipAddress>2732 Baker Blvd.</ShipAddress>
          <ShipCity>Eugene</ShipCity>
          <ShipRegion>OR</ShipRegion>
          <ShipPostalCode>97403</ShipPostalCode>
          <ShipCountry>USA</ShipCountry>
        </ShipInfo>
      </Order>
      <Order>
        <CustomerID>GREAL</CustomerID>
        <EmployeeID>4</EmployeeID>
        <OrderDate>1998-01-06T00:00:00</OrderDate>
        <RequiredDate>1998-02-03T00:00:00</RequiredDate>
        <ShipInfo ShippedDate="1998-02-04T00:00:00">
          <ShipVia>2</ShipVia>
          <Freight>719.78</Freight>
          <ShipName>Great Lakes Food Market</ShipName>
          <ShipAddress>2732 Baker Blvd.</ShipAddress>
          <ShipCity>Eugene</ShipCity>
          <ShipRegion>OR</ShipRegion>
          <ShipPostalCode>97403</ShipPostalCode>
          <ShipCountry>USA</ShipCountry>
        </ShipInfo>
      </Order>
      <Order>
        <CustomerID>GREAL</CustomerID>
        <EmployeeID>3</EmployeeID>
        <OrderDate>1998-03-09T00:00:00</OrderDate>
        <RequiredDate>1998-04-06T00:00:00</RequiredDate>
        <ShipInfo ShippedDate="1998-03-18T00:00:00">
          <ShipVia>2</ShipVia>
          <Freight>33.68</Freight>
          <ShipName>Great Lakes Food Market</ShipName>
          <ShipAddress>2732 Baker Blvd.</ShipAddress>
          <ShipCity>Eugene</ShipCity>
          <ShipRegion>OR</ShipRegion>
          <ShipPostalCode>97403</ShipPostalCode>
          <ShipCountry>USA</ShipCountry>
        </ShipInfo>
      </Order>
      <Order>
```

```
    <CustomerID>GREAL</CustomerID>
    <EmployeeID>3</EmployeeID>
    <OrderDate>1998-04-07T00:00:00</OrderDate>
    <RequiredDate>1998-05-05T00:00:00</RequiredDate>
    <ShipInfo ShippedDate="1998-04-15T00:00:00">
      <ShipVia>2</ShipVia>
      <Freight>25.19</Freight>
      <ShipName>Great Lakes Food Market</ShipName>
      <ShipAddress>2732 Baker Blvd.</ShipAddress>
      <ShipCity>Eugene</ShipCity>
      <ShipRegion>OR</ShipRegion>
      <ShipPostalCode>97403</ShipPostalCode>
      <ShipCountry>USA</ShipCountry>
    </ShipInfo>
  </Order>
  <Order>
    <CustomerID>GREAL</CustomerID>
    <EmployeeID>4</EmployeeID>
    <OrderDate>1998-04-22T00:00:00</OrderDate>
    <RequiredDate>1998-05-20T00:00:00</RequiredDate>
    <ShipInfo>
      <ShipVia>3</ShipVia>
      <Freight>18.84</Freight>
      <ShipName>Great Lakes Food Market</ShipName>
      <ShipAddress>2732 Baker Blvd.</ShipAddress>
      <ShipCity>Eugene</ShipCity>
      <ShipRegion>OR</ShipRegion>
      <ShipPostalCode>97403</ShipPostalCode>
      <ShipCountry>USA</ShipCountry>
    </ShipInfo>
  </Order>
  <Order>
    <CustomerID>GREAL</CustomerID>
    <EmployeeID>4</EmployeeID>
    <OrderDate>1998-04-30T00:00:00</OrderDate>
    <RequiredDate>1998-06-11T00:00:00</RequiredDate>
    <ShipInfo>
      <ShipVia>3</ShipVia>
      <Freight>14.01</Freight>
      <ShipName>Great Lakes Food Market</ShipName>
      <ShipAddress>2732 Baker Blvd.</ShipAddress>
      <ShipCity>Eugene</ShipCity>
      <ShipRegion>OR</ShipRegion>
      <ShipPostalCode>97403</ShipPostalCode>
      <ShipCountry>USA</ShipCountry>
    </ShipInfo>
  </Order>
  <Order>
    <CustomerID>HUNGC</CustomerID>
    <EmployeeID>3</EmployeeID>
    <OrderDate>1996-12-06T00:00:00</OrderDate>
    <RequiredDate>1997-01-03T00:00:00</RequiredDate>
    <ShipInfo ShippedDate="1996-12-09T00:00:00">
      <ShipVia>2</ShipVia>
      <Freight>20.12</Freight>
      <ShipName>Hungry Coyote Import Store</ShipName>
      <ShipAddress>City Center Plaza 516 Main St.</ShipAddress>
      <ShipCity>Elgin</ShipCity>
      <ShipRegion>OR</ShipRegion>
      <ShipPostalCode>97827</ShipPostalCode>
      <ShipCountry>USA</ShipCountry>
    </ShipInfo>
  </Order>
  <Order>
    <CustomerID>HUNGC</CustomerID>
    <EmployeeID>1</EmployeeID>
    <OrderDate>1996-12-25T00:00:00</OrderDate>
    <RequiredDate>1997-01-22T00:00:00</RequiredDate>
    <ShipInfo ShippedDate="1997-01-03T00:00:00">
```

```
        <ShipVia>3</ShipVia>
        <Freight>30.34</Freight>
        <ShipName>Hungry Coyote Import Store</ShipName>
        <ShipAddress>City Center Plaza 516 Main St.</ShipAddress>
        <ShipCity>Elgin</ShipCity>
        <ShipRegion>OR</ShipRegion>
        <ShipPostalCode>97827</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>HUNGC</CustomerID>
      <EmployeeID>3</EmployeeID>
      <OrderDate>1997-01-15T00:00:00</OrderDate>
      <RequiredDate>1997-02-12T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-01-24T00:00:00">
        <ShipVia>1</ShipVia>
        <Freight>0.2</Freight>
        <ShipName>Hungry Coyote Import Store</ShipName>
        <ShipAddress>City Center Plaza 516 Main St.</ShipAddress>
        <ShipCity>Elgin</ShipCity>
        <ShipRegion>OR</ShipRegion>
        <ShipPostalCode>97827</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>HUNGC</CustomerID>
      <EmployeeID>4</EmployeeID>
      <OrderDate>1997-07-16T00:00:00</OrderDate>
      <RequiredDate>1997-08-13T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-07-21T00:00:00">
        <ShipVia>1</ShipVia>
        <Freight>45.13</Freight>
        <ShipName>Hungry Coyote Import Store</ShipName>
        <ShipAddress>City Center Plaza 516 Main St.</ShipAddress>
        <ShipCity>Elgin</ShipCity>
        <ShipRegion>OR</ShipRegion>
        <ShipPostalCode>97827</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>HUNGC</CustomerID>
      <EmployeeID>8</EmployeeID>
      <OrderDate>1997-09-08T00:00:00</OrderDate>
      <RequiredDate>1997-10-06T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-10-15T00:00:00">
        <ShipVia>1</ShipVia>
        <Freight>111.29</Freight>
        <ShipName>Hungry Coyote Import Store</ShipName>
        <ShipAddress>City Center Plaza 516 Main St.</ShipAddress>
        <ShipCity>Elgin</ShipCity>
        <ShipRegion>OR</ShipRegion>
        <ShipPostalCode>97827</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>LAZYK</CustomerID>
      <EmployeeID>1</EmployeeID>
      <OrderDate>1997-03-21T00:00:00</OrderDate>
      <RequiredDate>1997-04-18T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-04-10T00:00:00">
        <ShipVia>3</ShipVia>
        <Freight>7.48</Freight>
        <ShipName>Lazy K Kountry Store</ShipName>
        <ShipAddress>12 Orchestra Terrace</ShipAddress>
        <ShipCity>Walla Walla</ShipCity>
        <ShipRegion>WA</ShipRegion>
        <ShipPostalCode>99362</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>LAZYK</CustomerID>
      <EmployeeID>8</EmployeeID>
      <OrderDate>1997-05-22T00:00:00</OrderDate>
      <RequiredDate>1997-06-19T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-06-26T00:00:00">
        <ShipVia>2</ShipVia>
        <Freight>11.92</Freight>
        <ShipName>Lazy K Kountry Store</ShipName>
        <ShipAddress>12 Orchestra Terrace</ShipAddress>
        <ShipCity>Walla Walla</ShipCity>
        <ShipRegion>WA</ShipRegion>
        <ShipPostalCode>99362</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>LETSS</CustomerID>
      <EmployeeID>1</EmployeeID>
      <OrderDate>1997-06-25T00:00:00</OrderDate>
      <RequiredDate>1997-07-23T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-07-04T00:00:00">
        <ShipVia>2</ShipVia>
        <Freight>13.73</Freight>
        <ShipName>Let's Stop N Shop</ShipName>
        <ShipAddress>87 Polk St. Suite 5</ShipAddress>
        <ShipCity>San Francisco</ShipCity>
        <ShipRegion>CA</ShipRegion>
        <ShipPostalCode>94117</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>LETSS</CustomerID>
      <EmployeeID>8</EmployeeID>
      <OrderDate>1997-10-27T00:00:00</OrderDate>
      <RequiredDate>1997-11-24T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-11-05T00:00:00">
        <ShipVia>2</ShipVia>
        <Freight>51.44</Freight>
        <ShipName>Let's Stop N Shop</ShipName>
        <ShipAddress>87 Polk St. Suite 5</ShipAddress>
        <ShipCity>San Francisco</ShipCity>
        <ShipRegion>CA</ShipRegion>
        <ShipPostalCode>94117</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>LETSS</CustomerID>
      <EmployeeID>6</EmployeeID>
      <OrderDate>1997-11-10T00:00:00</OrderDate>
      <RequiredDate>1997-12-08T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1997-11-21T00:00:00">
        <ShipVia>2</ShipVia>
        <Freight>45.97</Freight>
        <ShipName>Let's Stop N Shop</ShipName>
        <ShipAddress>87 Polk St. Suite 5</ShipAddress>
        <ShipCity>San Francisco</ShipCity>
        <ShipRegion>CA</ShipRegion>
        <ShipPostalCode>94117</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
    <Order>
      <CustomerID>LETSS</CustomerID>
      <EmployeeID>4</EmployeeID>
      <OrderDate>1998-02-12T00:00:00</OrderDate>
      <RequiredDate>1998-03-12T00:00:00</RequiredDate>
      <ShipInfo ShippedDate="1998-02-13T00:00:00">
        <ShipVia>2</ShipVia>
        <Freight>90.97</Freight>
        <ShipName>Let's Stop N Shop</ShipName>
        <ShipAddress>87 Polk St. Suite 5</ShipAddress>
        <ShipCity>San Francisco</ShipCity>
        <ShipRegion>CA</ShipRegion>
        <ShipPostalCode>94117</ShipPostalCode>
        <ShipCountry>USA</ShipCountry>
      </ShipInfo>
    </Order>
  </Orders>
</Root>
```

See also

- Sample XML Documents (LINQ to XML)

Sample XML File: Numerical Data (LINQ to XML)

1/23/2019 • 2 minutes to read • Edit Online

The following XML file is used in various examples in the LINQ to XML documentation. This file contains numerical data for summing, averaging, and grouping.

Data.xml

```
<Root>
  <TaxRate>7.25</TaxRate>
  <Data>
    <Category>A</Category>
    <Quantity>3</Quantity>
    <Price>24.50</Price>
  </Data>
  <Data>
    <Category>B</Category>
    <Quantity>1</Quantity>
    <Price>89.99</Price>
  </Data>
  <Data>
    <Category>A</Category>
    <Quantity>5</Quantity>
    <Price>4.95</Price>
  </Data>
  <Data>
    <Category>A</Category>
    <Quantity>3</Quantity>
    <Price>66.00</Price>
  </Data>
  <Data>
    <Category>B</Category>
    <Quantity>10</Quantity>
    <Price>.99</Price>
  </Data>
  <Data>
    <Category>A</Category>
    <Quantity>15</Quantity>
    <Price>29.00</Price>
  </Data>
  <Data>
    <Category>B</Category>
    <Quantity>8</Quantity>
    <Price>6.99</Price>
  </Data>
</Root>
```

See also

- Sample XML Documents (LINQ to XML)

Sample XML File: Numerical Data in a Namespace

1/23/2019 • 2 minutes to read • Edit Online

The following XML file is used in various examples in the LINQ to XML documentation. This file contains numerical data for summing, averaging, and grouping. The XML is in a namespace.

Data

```
<Root xmlns='http://www.adatum.com'>
  <TaxRate>7.25</TaxRate>
  <Data>
    <Category>A</Category>
    <Quantity>3</Quantity>
    <Price>24.50</Price>
  </Data>
  <Data>
    <Category>B</Category>
    <Quantity>1</Quantity>
    <Price>89.99</Price>
  </Data>
  <Data>
    <Category>A</Category>
    <Quantity>5</Quantity>
    <Price>4.95</Price>
  </Data>
  <Data>
    <Category>A</Category>
    <Quantity>3</Quantity>
    <Price>66.00</Price>
  </Data>
  <Data>
    <Category>B</Category>
    <Quantity>10</Quantity>
    <Price>.99</Price>
  </Data>
  <Data>
    <Category>A</Category>
    <Quantity>15</Quantity>
    <Price>29.00</Price>
  </Data>
  <Data>
    <Category>B</Category>
    <Quantity>8</Quantity>
    <Price>6.99</Price>
  </Data>
</Root>
```

See also

- Sample XML Documents (LINQ to XML)

Sample XML File: Books (LINQ to XML)

1/23/2019 • 2 minutes to read • Edit Online

The following XML file is used in various examples in the LINQ to XML documentation. The file contains information about books.

books.xml

```
<?xml version="1.0"?>
<Catalog>
   <Book id="bk101">
      <Author>Garghentini, Davide</Author>
      <Title>XML Developer's Guide</Title>
      <Genre>Computer</Genre>
      <Price>44.95</Price>
      <PublishDate>2000-10-01</PublishDate>
      <Description>An in-depth look at creating applications
      with XML.</Description>
   </Book>
   <Book id="bk102">
      <Author>Garcia, Debra</Author>
      <Title>Midnight Rain</Title>
      <Genre>Fantasy</Genre>
      <Price>5.95</Price>
      <PublishDate>2000-12-16</PublishDate>
      <Description>A former architect battles corporate zombies,
      an evil sorceress, and her own childhood to become queen
      of the world.</Description>
   </Book>
</Catalog>
```

See also

- Sample XML Documents (LINQ to XML)

Sample XML File: Consolidated Purchase Orders

1/23/2019 • 2 minutes to read • Edit Online

The following XML file is used in various examples in the LINQ to XML documentation. This file is a set of purchase orders with different shapes from multiple companies. Purchase orders from each company are in separate namespaces.

ConsolidatedPurchaseOrders.xml

```
<?xml version="1.0"?>
<PurchaseOrders xmlns="www.contoso.com">
  <PurchaseOrder
      PurchaseOrderNumber="99503"
      OrderDate="1999-10-20">
    <Address Type="Shipping">
      <Name>Ellen Adams</Name>
      <Street>123 Maple Street</Street>
      <City>Mill Valley</City>
      <State>CA</State>
      <Zip>10999</Zip>
      <Country>USA</Country>
    </Address>
    <Address Type="Billing">
      <Name>Tai Yee</Name>
      <Street>8 Oak Avenue</Street>
      <City>Old Town</City>
      <State>PA</State>
      <Zip>95819</Zip>
      <Country>USA</Country>
    </Address>
    <DeliveryNotes>Please leave packages in shed by driveway.</DeliveryNotes>
    <Items>
      <Item PartNumber="872-AA">
        <ProductName>Lawnmower</ProductName>
        <Quantity>1</Quantity>
        <USPrice>148.95</USPrice>
        <Comment>Confirm this is electric</Comment>
      </Item>
      <Item PartNumber="926-AA">
        <ProductName>Baby Monitor</ProductName>
        <Quantity>2</Quantity>
        <USPrice>39.98</USPrice>
        <ShipDate>1999-05-21</ShipDate>
      </Item>
    </Items>
  </PurchaseOrder>
  <PurchaseOrder PurchaseOrderNumber="99505" OrderDate="1999-10-22">
    <Address Type="Shipping">
      <Name>Cristian Osorio</Name>
      <Street>456 Main Street</Street>
      <City>Buffalo</City>
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      <City>Seattle</City>
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```

See also

- Sample XML Documents (LINQ to XML)

Reference (LINQ to XML)

1/23/2019 • 2 minutes to read • Edit Online

This topic contains links to the LINQ to XML reference topics.

In This Section

For reference documentation for the LINQ to XML classes, see System.Xml.Linq.

For reference documentation for the extension methods that help you validate XML trees against an XSD file, see System.Xml.Schema.Extensions.

For reference documentation for the extension methods that enable you to evaluate XPath queries on an XML tree, see System.Xml.XPath.Extensions.

See also

- LINQ to XML (C#)

LINQ to ADO.NET (Portal Page)

1/23/2019 • 2 minutes to read • Edit Online

LINQ to ADO.NET enables you to query over any enumerable object in ADO.NET by using the Language-Integrated Query (LINQ) programming model.

NOTE

The LINQ to ADO.NET documentation is located in the ADO.NET section of the .NET Framework SDK: LINQ and ADO.NET.

There are three separate ADO.NET Language-Integrated Query (LINQ) technologies: LINQ to DataSet, LINQ to SQL, and LINQ to Entities. LINQ to DataSet provides richer, optimized querying over the DataSet, LINQ to SQL enables you to directly query SQL Server database schemas, and LINQ to Entities allows you to query an Entity Data Model.

LINQ to DataSet

The DataSet is one of the most widely used components in ADO.NET, and is a key element of the disconnected programming model that ADO.NET is built on. Despite this prominence, however, the DataSet has limited query capabilities.

LINQ to DataSet enables you to build richer query capabilities into DataSet by using the same query functionality that is available for many other data sources.

For more information, see LINQ to DataSet.

LINQ to SQL

LINQ to SQL provides a run-time infrastructure for managing relational data as objects. In LINQ to SQL, the data model of a relational database is mapped to an object model expressed in the programming language of the developer. When you execute the application, LINQ to SQL translates language-integrated queries in the object model into SQL and sends them to the database for execution. When the database returns the results, LINQ to SQL translates them back into objects that you can manipulate.

LINQ to SQL includes support for stored procedures and user-defined functions in the database, and for inheritance in the object model.

For more information, see LINQ to SQL.

LINQ to Entities

Through the Entity Data Model, relational data is exposed as objects in the .NET environment. This makes the object layer an ideal target for LINQ support, allowing developers to formulate queries against the database from the language used to build the business logic. This capability is known as LINQ to Entities. See LINQ to Entities for more information.

See also

- LINQ and ADO.NET
- Language-Integrated Query (LINQ) (C#)

Enabling a Data Source for LINQ Querying

1/23/2019 • 3 minutes to read • Edit Online

There are various ways to extend LINQ to enable any data source to be queried in the LINQ pattern. The data source might be a data structure, a Web service, a file system, or a database, to name some. The LINQ pattern makes it easy for clients to query a data source for which LINQ querying is enabled, because the syntax and pattern of the query does not change. The ways in which LINQ can be extended to these data sources include the following:

- Implementing the IEnumerable<T> interface in a type to enable LINQ to Objects querying of that type.
- Creating standard query operator methods such as Where and Select that extend a type, to enable custom LINQ querying of that type.
- Creating a provider for your data source that implements the IQueryable<T> interface. A provider that implements this interface receives LINQ queries in the form of expression trees, which it can execute in a custom way, for example remotely.
- Creating a provider for your data source that takes advantage of an existing LINQ technology. Such a provider would enable not only querying, but also insert, update, and delete operations and mapping for user-defined types.

This topic discusses these options.

How to Enable LINQ Querying of Your Data Source

In-Memory Data

There are two ways you can enable LINQ querying of in-memory data. If the data is of a type that implements IEnumerable<T>, you can query the data by using LINQ to Objects. If it does not make sense to enable enumeration of your type by implementing the IEnumerable<T> interface, you can define LINQ standard query operator methods in that type or create LINQ standard query operator methods that extend the type. Custom implementations of the standard query operators should use deferred execution to return the results.

Remote Data

The best option for enabling LINQ querying of a remote data source is to implement the IQueryable<T> interface. However, this differs from extending a provider such as LINQ to SQL for a data source. No provider models for extending existing LINQ technologies, such as LINQ to SQL, to other types of data source are available in Visual Studio 2008.

IQueryable LINQ Providers

LINQ providers that implement IQueryable<T> can vary widely in their complexity. This section discusses the different levels of complexity.

A less complex `IQueryable` provider might interface with a single method of a Web service. This type of provider is very specific because it expects specific information in the queries that it handles. It has a closed type system, perhaps exposing a single result type. Most of the execution of the query occurs locally, for example by using the Enumerable implementations of the standard query operators. A less complex provider might examine only one method call expression in the expression tree that represents the query, and let the remaining logic of the query be handled elsewhere.

An `IQueryable` provider of medium complexity might target a data source that has a partially expressive query language. If it targets a Web service, it might interface with more than one method of the Web service and select the method to call based on the question that the query poses. A provider of medium complexity would have a richer type system than a simple provider, but it would still be a fixed type system. For example, the provider might expose types that have one-to-many relationships that can be traversed, but it would not provide mapping technology for user-defined types.

A complex `IQueryable` provider, such as the LINQ to SQL provider, might translate complete LINQ queries to an expressive query language, such as SQL. A complex provider is more general than a less complex provider, because it can handle a wider variety of questions in the query. It also has an open type system and therefore must contain extensive infrastructure to map user-defined types. Developing a complex provider requires a significant amount of effort.

See also

- IQueryable<T>
- IEnumerable<T>
- Enumerable
- Standard Query Operators Overview (C#)
- LINQ to Objects (C#)

Visual Studio IDE and Tools Support for LINQ (C#)

1/23/2019 • 2 minutes to read • Edit Online

The Visual Studio integrated development environment (IDE) provides the following features that support LINQ application development:

Object Relational Designer

The Object Relational Designer is a visual design tool that you can use in LINQ to SQL applications to generate classes in C# that represent the relational data in an underlying database. For more information, see LINQ to SQL Tools in Visual Studio.

SQLMetal Command Line Tool

SQLMetal is a command-line tool that can be used in build processes to generate classes from existing databases for use in LINQ to SQL applications. For more information, see SqlMetal.exe (Code Generation Tool).

LINQ-Aware Code Editor

The C# code editor supports LINQ extensively with IntelliSense and formatting capabilities.

Visual Studio Debugger Support

The Visual Studio debugger supports debugging of query expressions. For more information, see Debugging LINQ.

See also

- Language-Integrated Query (LINQ) (C#)

Contents

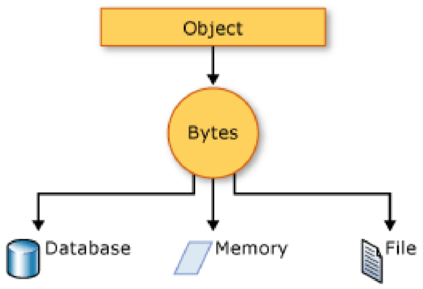
Serialization (C#)

9/5/2018 • 3 minutes to read • Edit Online

Serialization is the process of converting an object into a stream of bytes to store the object or transmit it to memory, a database, or a file. Its main purpose is to save the state of an object in order to be able to recreate it when needed. The reverse process is called deserialization.

How serialization works

This illustration shows the overall process of serialization.



The object is serialized to a stream, which carries not just the data, but information about the object's type, such as its version, culture, and assembly name. From that stream, it can be stored in a database, a file, or memory.

Uses for serialization

Serialization allows the developer to save the state of an object and recreate it as needed, providing storage of objects as well as data exchange. Through serialization, a developer can perform actions like sending the object to a remote application by means of a Web Service, passing an object from one domain to another, passing an object through a firewall as an XML string, or maintaining security or user-specific information across applications.

Making an object serializable

To serialize an object, you need the object to be serialized, a stream to contain the serialized object, and a Formatter. System.Runtime.Serialization contains the classes necessary for serializing and deserializing objects.

Apply the SerializableAttribute attribute to a type to indicate that instances of this type can be serialized. An exception is thrown if you attempt to serialize but the type doesn't have the SerializableAttribute attribute.

If you don't want a field within your class to be serializable, apply the NonSerializedAttribute attribute. If a field of a serializable type contains a pointer, a handle, or some other data structure that is specific to a particular environment, and the field cannot be meaningfully reconstituted in a different environment, then you may want to make it nonserializable.

If a serialized class contains references to objects of other classes that are marked SerializableAttribute, those objects will also be serialized.

Binary and XML serialization

You can use binary or XML serialization. In binary serialization, all members, even members that are read-only, are serialized, and performance is enhanced. XML serialization provides more readable code, and greater flexibility of object sharing and usage for interoperability purposes.

Binary serialization

Binary serialization uses binary encoding to produce compact serialization for uses such as storage or socketbased network streams.

XML serialization

XML serialization serializes the public fields and properties of an object, or the parameters and return values of methods, into an XML stream that conforms to a specific XML Schema definition language (XSD) document. XML serialization results in strongly typed classes with public properties and fields that are converted to XML. System.Xml.Serialization contains the classes necessary for serializing and deserializing XML.

You apply attributes to classes and class members to control the way the XmlSerializer serializes or deserializes an instance of the class.

Basic and custom serialization

Serialization can be performed in two ways, basic and custom. Basic serialization uses the .NET Framework to automatically serialize the object.

Basic serialization

The only requirement in basic serialization is that the object has the SerializableAttribute attribute applied. The NonSerializedAttribute can be used to keep specific fields from being serialized.

When you use basic serialization, the versioning of objects may create problems. You would use custom serialization when versioning issues are important. Basic serialization is the easiest way to perform serialization, but it does not provide much control over the process.

Custom serialization

In custom serialization, you can specify exactly which objects will be serialized and how it will be done. The class must be marked SerializableAttribute and implement the ISerializable interface.

If you want your object to be deserialized in a custom manner as well, you must use a custom constructor.

Designer serialization

Designer serialization is a special form of serialization that involves the kind of object persistence associated with development tools. Designer serialization is the process of converting an object graph into a source file that can later be used to recover the object graph. A source file can contain code, markup, or even SQL table information.

Related Topics and Examples

Walkthrough: Persisting an Object in Visual Studio (C#)
Demonstrates how serialization can be used to persist an object's data between instances, allowing you to store values and retrieve them the next time the object is instantiated.

How to: Read Object Data from an XML File (C#)
Shows how to read object data that was previously written to an XML file using the XmlSerializer class.

How to: Write Object Data to an XML File (C#)
Shows how to write the object from a class to an XML file using the XmlSerializer class.

How to: Write Object Data to an XML File (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example writes the object from a class to an XML file using the XmlSerializer class.

Example

```
public class XMLWrite
{

   static void Main(string[] args)
    {
        WriteXML();
    }

    public class Book
    {
        public String title;
    }

    public static void WriteXML()
    {
        Book overview = new Book();
        overview.title = "Serialization Overview";
        System.Xml.Serialization.XmlSerializer writer =
            new System.Xml.Serialization.XmlSerializer(typeof(Book));

        var path = Environment.GetFolderPath(Environment.SpecialFolder.MyDocuments) +
"//SerializationOverview.xml";
        System.IO.FileStream file = System.IO.File.Create(path);

        writer.Serialize(file, overview);
        file.Close();
    }
}
```

Compiling the Code

The class must have a public constructor without parameters.

Robust Programming

The following conditions may cause an exception:

- The class being serialized does not have a public, parameterless constructor.
- The file exists and is read-only (IOException).
- The path is too long (PathTooLongException).
- The disk is full (IOException).

.NET Framework Security

This example creates a new file, if the file does not already exist. If an application needs to create a file, that application needs `Create` access for the folder. If the file already exists, the application needs only `Write` access, a lesser privilege. Where possible, it is more secure to create the file during deployment, and only grant `Read` access to a single file, rather than `Create` access for a folder.

See also

- StreamWriter
- How to: Read Object Data from an XML File (C#)
- Serialization (C#)

How to: Read Object Data from an XML File (C#)

1/23/2019 • 2 minutes to read • Edit Online

This example reads object data that was previously written to an XML file using the XmlSerializer class.

Example

```
public class Book
{
    public String title;
}

public void ReadXML()
{
    // First write something so that there is something to read ...
    var b = new Book { title = "Serialization Overview" };
    var writer = new System.Xml.Serialization.XmlSerializer(typeof(Book));
    var wfile = new System.IO.StreamWriter(@"c:\temp\SerializationOverview.xml");
    writer.Serialize(wfile, b);
    wfile.Close();

    // Now we can read the serialized book ...
    System.Xml.Serialization.XmlSerializer reader =
        new System.Xml.Serialization.XmlSerializer(typeof(Book));
    System.IO.StreamReader file = new System.IO.StreamReader(
        @"c:\temp\SerializationOverview.xml");
    Book overview =  (Book)reader.Deserialize(file);
    file.Close();

    Console.WriteLine(overview.title);

}
```

Compiling the Code

Replace the file name "c:\temp\SerializationOverview.xml" with the name of the file containing the serialized data. For more information about serializing data, see How to: Write Object Data to an XML File (C#).

The class must have a public constructor without parameters.

Only public properties and fields are deserialized.

Robust Programming

The following conditions may cause an exception:

- The class being serialized does not have a public, parameterless constructor.
- The data in the file does not represent data from the class to be deserialized.
- The file does not exist (IOException).

.NET Framework Security

Always verify inputs, and never deserialize data from an untrusted source. The re-created object runs on a local computer with the permissions of the code that deserialized it. Verify all inputs before using the data in your application.

See also

- StreamWriter
- How to: Write Object Data to an XML File (C#)
- Serialization (C#)
- C# Programming Guide

Walkthrough: persisting an object using C#

1/23/2019 • 4 minutes to read • Edit Online

You can use serialization to persist an object's data between instances, which enables you to store values and retrieve them the next time that the object is instantiated.

In this walkthrough, you will create a basic `Loan` object and persist its data to a file. You will then retrieve the data from the file when you re-create the object.

IMPORTANT

This example creates a new file if the file does not already exist. If an application must create a file, that application must have `Create` permission for the folder. Permissions are set by using access control lists. If the file already exists, the application needs only `Write` permission, a lesser permission. Where possible, it's more secure to create the file during deployment and only grant `Read` permissions to a single file (instead of Create permissions for a folder). Also, it's more secure to write data to user folders than to the root folder or the Program Files folder.

IMPORTANT

This example stores data in a binary format file. These formats should not be used for sensitive data, such as passwords or credit-card information.

Prerequisites

- To build and run, install the .NET Core SDK.
- Install your favorite code editor, if you haven't already.

TIP

Need to install a code editor? Try Visual Studio!

- The example requires C# 7.3. See Select the C# language version

You can examine the sample code online at the .NET samples GitHub repository.

Creating the loan object

The first step is to create a `Loan` class and a console application that uses the class:

1. Create a new application. Type `dotnet new console -o serialization` to create a new console application in a subdirectory named `serialization`.
2. Open the application in your editor, and add a new class named `Loan.cs`.
3. Add the following code to your `Loan` class:

```
public class Loan : INotifyPropertyChanged
 {
     public double LoanAmount { get; set; }
     public double InterestRate { get; set; }

     [field:NonSerialized()]
     public DateTime TimeLastLoaded { get; set; }

     public int Term { get; set; }

     private string customer;
     public string Customer
     {
         get { return customer; }
         set
         {
             customer = value;
             PropertyChanged?.Invoke(this,
               new PropertyChangedEventArgs(nameof(Customer)));
         }
     }

     [field: NonSerialized()]
     public event System.ComponentModel.PropertyChangedEventHandler PropertyChanged;

     public Loan(double loanAmount,
                 double interestRate,
                 int term,
                 string customer)
     {
         this.LoanAmount = loanAmount;
         this.InterestRate = interestRate;
         this.Term = term;
         this.customer = customer;
     }

 }
```

You will also have to create an application that uses the `Loan` class.

Serialize the loan object

1. Open `Program.cs`. Add the following code:

```
Loan TestLoan = new Loan(10000.0, 0.075, 36, "Neil Black");
```

Add an event handler for the `PropertyChanged` event, and a few lines to modify the `Loan` object and display the changes. You can see the additions in the following code:

```
TestLoan.PropertyChanged += (_, __) => Console.WriteLine($"New customer value: {TestLoan.Customer}");

TestLoan.Customer = "Henry Clay";
Console.WriteLine(TestLoan.InterestRate);
TestLoan.InterestRate = 7.1;
Console.WriteLine(TestLoan.InterestRate);
```

At this point, you can run the code, and see the current output:

```
New customer value: Henry Clay
7.5
7.1
```

Running this application repeatedly always writes the same values. A new Loan object is created every time you run the program. In the real world, interest rates change periodically, but not necessarily every time that the application is run. Serialization code means you preserve the most recent interest rate between instances of the application. In the next step, you will do just that by adding serialization to the Loan class.

Using Serialization to Persist the Object

In order to persist the values for the Loan class, you must first mark the class with the `Serializable` attribute. Add the following code above the Loan class definition:

```
[Serializable()]
```

The SerializableAttribute tells the compiler that everything in the class can be persisted to a file. Because the `PropertyChanged` event does not represent part of the object graph that should be stored, it should not be serialized. Doing so would serialize all objects that are attached to that event. You can add the NonSerializedAttribute to the field declaration for the `PropertyChanged` event handler.

```
[field: NonSerialized()]
public event System.ComponentModel.PropertyChangedEventHandler PropertyChanged;
```

Beginning with C# 7.3, you can attach attributes to the backing field of an auto-implemented property using the `field` target value. The following code adds a `TimeLastLoaded` property and marks it as not serializable:

```
[field:NonSerialized()]
public DateTime TimeLastLoaded { get; set; }
```

The next step is to add the serialization code to the LoanApp application. In order to serialize the class and write it to a file, you use the System.IO and System.Runtime.Serialization.Formatters.Binary namespaces. To avoid typing the fully qualified names, you can add references to the necessary namespaces as shown in the following code:

```
using System.IO;
using System.Runtime.Serialization.Formatters.Binary;
```

The next step is to add code to deserialize the object from the file when the object is created. Add a constant to the class for the serialized data's file name as shown in the following code:

```
const string FileName = @"../../../SavedLoan.bin";
```

Next, add the following code after the line that creates the `TestLoan` object:

```
if (File.Exists(FileName))
{
    Console.WriteLine("Reading saved file");
    Stream openFileStream = File.OpenRead(FileName);
    BinaryFormatter deserializer = new BinaryFormatter();
    TestLoan = (Loan)deserializer.Deserialize(openFileStream);
    TestLoan.TimeLastLoaded = DateTime.Now;
    openFileStream.Close();
}
```

You first must check that the file exists. If it exists, create a Stream class to read the binary file and a BinaryFormatter class to translate the file. You also need to convert from the stream type to the Loan object type.

Next you must add code to serialize the class to a file. Add the following code after the existing code in the `Main` method:

```
Stream SaveFileStream = File.Create(FileName);
BinaryFormatter serializer = new BinaryFormatter();
serializer.Serialize(SaveFileStream, TestLoan);
SaveFileStream.Close();
```

At this point, you can again build and run the application. The first time it runs, notice that the interest rates starts at 7.5, and then changes to 7.1. Close the application and then run it again. Now, the application prints the message that it has read the saved file, and the interest rate is 7.1 even before the code that changes it.

See also

- Serialization (C#)
- C# Programming Guide

Contents

Programming Concepts (C#)

11/9/2018 • 2 minutes to read • Edit Online

This section explains programming concepts in the C# language.

In This Section

TITLE	DESCRIPTION
Assemblies and the Global Assembly Cache (C#)	Describes how to create and use assemblies.
Asynchronous Programming with async and await (C#)	Describes how to write asynchronous solutions by using the async and await keywords in C#. Includes a walkthrough.
Attributes (C#)	Discusses how to provide additional information about programming elements such as types, fields, methods, and properties by using attributes.
Caller Information (C#)	Describes how to obtain information about the caller of a method. This information includes the file path and the line number of the source code and the member name of the caller.
Collections (C#)	Describes some of the types of collections provided by the .NET Framework. Demonstrates how to use simple collections and collections of key/value pairs.
Covariance and Contravariance (C#)	Shows how to enable implicit conversion of generic type parameters in interfaces and delegates.
Expression Trees (C#)	Explains how you can use expression trees to enable dynamic modification of executable code.
Iterators (C#)	Describes iterators, which are used to step through collections and return elements one at a time.
Language-Integrated Query (LINQ) (C#)	Discusses the powerful query capabilities in the language syntax of C#, and the model for querying relational databases, XML documents, datasets, and in-memory collections.
Object-Oriented Programming (C#)	Describes common object-oriented concepts, including encapsulation, inheritance, and polymorphism.
Reflection (C#)	Explains how to 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 and invoke its methods or access its fields and properties.
Serialization (C#)	Describes key concepts in binary, XML, and SOAP serialization.

Related Sections

Performance Tips	Discusses several basic rules that may help you increase the performance of your application.

Assemblies and the Global Assembly Cache (C#)

1/23/2019 • 3 minutes to read • Edit Online

Assemblies form the fundamental unit of deployment, version control, reuse, activation scoping, and security permissions for a .NET-based application. Assemblies take the form of an executable (.exe) file or dynamic link library (.dll) file, and are the building blocks of the .NET Framework. They provide the common language runtime with the information it needs to be aware of type implementations. You can think of an assembly as a collection of types and resources that form a logical unit of functionality and are built to work together.

Assemblies can contain one or more modules. For example, larger projects may be planned in such a way that several individual developers work on separate modules, all coming together to create a single assembly. For more information about modules, see the topic How to: Build a Multifile Assembly.

Assemblies have the following properties:

- Assemblies are implemented as .exe or .dll files.
- You can share an assembly between applications by putting it in the global assembly cache. Assemblies must be strong-named before they can be included in the global assembly cache. For more information, see Strong-Named Assemblies.
- Assemblies are only loaded into memory if they are required. If they are not used, they are not loaded. This means that assemblies can be an efficient way to manage resources in larger projects.
- You can programmatically obtain information about an assembly by using reflection. For more information, see Reflection (C#).
- If you want to load an assembly only to inspect it, use a method such as ReflectionOnlyLoadFrom.

Assembly Manifest

Within every assembly, there is an *assembly manifest*. Similar to a table of contents, the assembly manifest contains the following:

- The assembly's identity (its name and version).
- A file table describing all the other files that make up the assembly, for example, any other assemblies you created that your .exe or .dll file relies on, or even bitmap or Readme files.
- An *assembly reference list*, which is a list of all external dependencies—.dlls or other files your application needs that may have been created by someone else. Assembly references contain references to both global and private objects. Global objects reside in the global assembly cache, an area available to other applications. Private objects must be in a directory at either the same level as or below the directory in which your application is installed.

Because assemblies contain information about content, versioning, and dependencies, the applications you create with C# do not rely on Windows registry values to function properly. Assemblies reduce .dll conflicts and make your applications more reliable and easier to deploy. In many cases, you can install a .NET-based application simply by copying its files to the target computer.

For more information see Assembly Manifest.

Adding a Reference to an Assembly

To use an assembly, you must add a reference to it. Next, you use the using directive to choose the namespace of the items you want to use. Once an assembly is referenced and imported, all the accessible classes, properties, methods, and other members of its namespaces are available to your application as if their code were part of your source file.

In C#, you can also use two versions of the same assembly in a single application. For more information, see extern alias.

Creating an Assembly

Compile your application by clicking **Build** on the **Build** menu or by building it from the command line using the command-line compiler. For details about building assemblies from the command line, see Command-line Building With csc.exe.

NOTE

To build an assembly in Visual Studio, on the **Build** menu choose **Build**.

See also

- C# Programming Guide
- Assemblies in the Common Language Runtime
- Friend Assemblies (C#)
- How to: Share an Assembly with Other Applications (C#)
- How to: Load and Unload Assemblies (C#)
- How to: Determine If a File Is an Assembly (C#)
- How to: Create and Use Assemblies Using the Command Line (C#)
- Walkthrough: Embedding Types from Managed Assemblies in Visual Studio (C#)
- Walkthrough: Embedding Type Information from Microsoft Office Assemblies in Visual Studio (C#)

Asynchronous programming with async and await (C#)

2/6/2019 • 16 minutes to read • Edit Online

You can avoid performance bottlenecks and enhance the overall responsiveness of your application by using asynchronous programming. However, traditional techniques for writing asynchronous applications can be complicated, making them difficult to write, debug, and maintain.

C# 5 introduced a simplified approach, async programming, that leverages asynchronous support in the .NET Framework 4.5 and higher, .NET Core, and the Windows Runtime. The compiler does the difficult work that the developer used to do, and your application retains a logical structure that resembles synchronous code. As a result, you get all the advantages of asynchronous programming with a fraction of the effort.

This topic provides an overview of when and how to use async programming and includes links to support topics that contain details and examples.

Async improves responsiveness

Asynchrony is essential for activities that are potentially blocking, such as web access. Access to a web resource sometimes is slow or delayed. If such an activity is blocked in a synchronous process, the entire application must wait. In an asynchronous process, the application can continue with other work that doesn't depend on the web resource until the potentially blocking task finishes.

The following table shows typical areas where asynchronous programming improves responsiveness. The listed APIs from .NET and the Windows Runtime contain methods that support async programming.

APPLICATION AREA	.NET TYPES WITH ASYNC METHODS	WINDOWS RUNTIME TYPES WITH ASYNC METHODS
Web access	HttpClient	SyndicationClient
Working with files	StreamWriter, StreamReader, XmlReader	StorageFile
Working with images		MediaCapture, BitmapEncoder, BitmapDecoder
WCF programming	Synchronous and Asynchronous Operations	

Asynchrony proves especially valuable for applications that access the UI thread because all UI-related activity usually shares one thread. If any process is blocked in a synchronous application, all are blocked. Your application stops responding, and you might conclude that it has failed when instead it's just waiting.

When you use asynchronous methods, the application continues to respond to the UI. You can resize or minimize a window, for example, or you can close the application if you don't want to wait for it to finish.

The async-based approach adds the equivalent of an automatic transmission to the list of options that you can choose from when designing asynchronous operations. That is, you get all the benefits of traditional asynchronous programming but with much less effort from the developer.

Async methods are easier to write

The async and await keywords in C# are the heart of async programming. By using those two keywords, you can use resources in the .NET Framework, .NET Core, or the Windows Runtime to create an asynchronous method almost as easily as you create a synchronous method. Asynchronous methods that you define by using the `async` keyword are referred to as *async methods*.

The following example shows an async method. Almost everything in the code should look completely familiar to you. The comments call out the features that you add to create the asynchrony.

You can find a complete Windows Presentation Foundation (WPF) example file at the end of this topic, and you can download the sample from Async Sample: Example from "Asynchronous Programming with Async and Await".

```
// Three things to note in the signature:
//  - The method has an async modifier.
//  - The return type is Task or Task<T>. (See "Return Types" section.)
//    Here, it is Task<int> because the return statement returns an integer.
//  - The method name ends in "Async."
async Task<int> AccessTheWebAsync()
{
    // You need to add a reference to System.Net.Http to declare client.
    using (HttpClient client = new HttpClient())
    {
        // GetStringAsync returns a Task<string>. That means that when you await the
        // task you'll get a string (urlContents).
        Task<string> getStringTask = client.GetStringAsync("https://docs.microsoft.com");

        // You can do work here that doesn't rely on the string from GetStringAsync.
        DoIndependentWork();

        // The await operator suspends AccessTheWebAsync.
        //  - AccessTheWebAsync can't continue until getStringTask is complete.
        //  - Meanwhile, control returns to the caller of AccessTheWebAsync.
        //  - Control resumes here when getStringTask is complete.
        //  - The await operator then retrieves the string result from getStringTask.
        string urlContents = await getStringTask;

        // The return statement specifies an integer result.
        // Any methods that are awaiting AccessTheWebAsync retrieve the length value.
        return urlContents.Length;
    }
}
```

If `AccessTheWebAsync` doesn't have any work that it can do between calling `GetStringAsync` and awaiting its completion, you can simplify your code by calling and awaiting in the following single statement.

```
string urlContents = await client.GetStringAsync("https://docs.microsoft.com");
```

The following characteristics summarize what makes the previous example an async method.

- The method signature includes an `async` modifier.
- The name of an async method, by convention, ends with an "Async" suffix.
- The return type is one of the following types:
    - Task<TResult> if your method has a return statement in which the operand has type `TResult`.
    - Task if your method has no return statement or has a return statement with no operand.
    - `void` if you're writing an async event handler.

- Any other type that has a `GetAwaiter` method (starting with C# 7.0).

  For more information, see the Return Types and Parameters section.

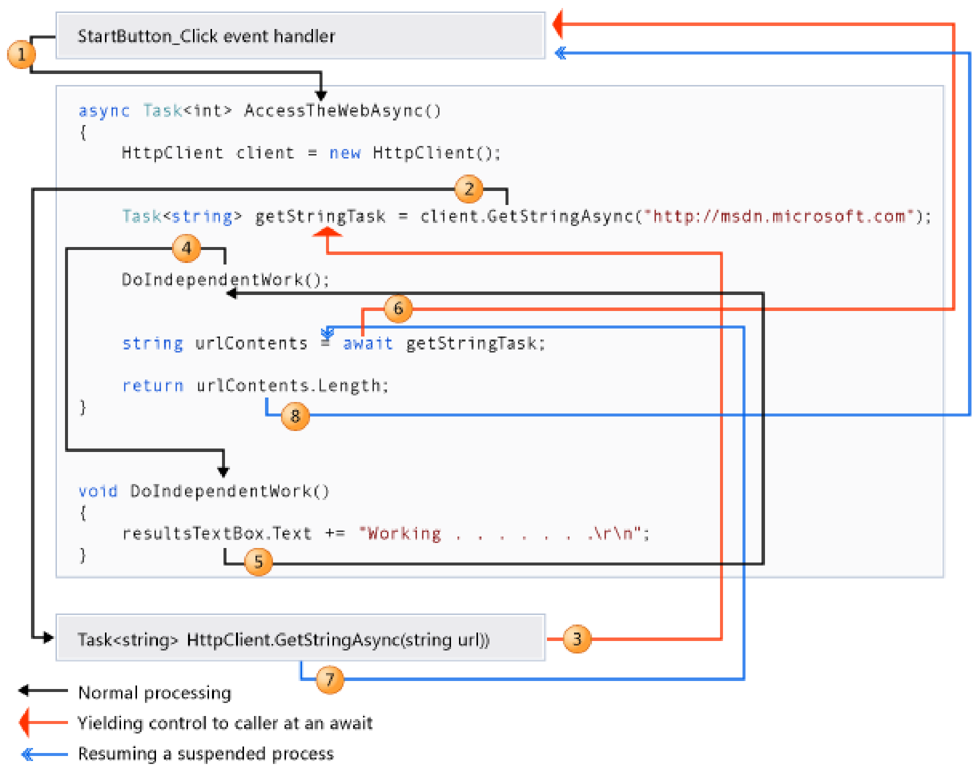
- The method usually includes at least one await expression, which marks a point where the method can't continue until the awaited asynchronous operation is complete. In the meantime, the method is suspended, and control returns to the method's caller. The next section of this topic illustrates what happens at the suspension point.

In async methods, you use the provided keywords and types to indicate what you want to do, and the compiler does the rest, including keeping track of what must happen when control returns to an await point in a suspended method. Some routine processes, such as loops and exception handling, can be difficult to handle in traditional asynchronous code. In an async method, you write these elements much as you would in a synchronous solution, and the problem is solved.

For more information about asynchrony in previous versions of the .NET Framework, see TPL and Traditional .NET Framework Asynchronous Programming.

What happens in an async method

The most important thing to understand in asynchronous programming is how the control flow moves from method to method. The following diagram leads you through the process.


StartButton_Click event handler
1
2
3
4
5
6
7
8
Task<string> HttpClient.GetStringAsync(string url))
Normal processing
Yielding control to caller at an await
Resuming a suspended process

```
async Task<int> AccessTheWebAsync()
{
    HttpClient client = new HttpClient();

    Task<string> getStringTask = client.GetStringAsync("http://msdn.microsoft.com");

    DoIndependentWork();

    string urlContents = await getStringTask;

    return urlContents.Length;
}

void DoIndependentWork()
{
    resultsTextBox.Text += "Working . . . . . . .\r\n";
}
```

The numbers in the diagram correspond to the following steps.

1. An event handler calls and awaits the `AccessTheWebAsync` async method.

2. `AccessTheWebAsync` creates an HttpClient instance and calls the GetStringAsync asynchronous method to download the contents of a website as a string.

3. Something happens in `GetStringAsync` that suspends its progress. Perhaps it must wait for a website to download or some other blocking activity. To avoid blocking resources, `GetStringAsync` yields control to its caller, `AccessTheWebAsync`.

   `GetStringAsync` returns a Task<TResult> where `TResult` is a string, and `AccessTheWebAsync` assigns the task to the `getStringTask` variable. The task represents the ongoing process for the call to `GetStringAsync`, with a commitment to produce an actual string value when the work is complete.

4. Because `getStringTask` hasn't been awaited yet, `AccessTheWebAsync` can continue with other work that doesn't depend on the final result from `GetStringAsync`. That work is represented by a call to the synchronous method `DoIndependentWork`.

5. `DoIndependentWork` is a synchronous method that does its work and returns to its caller.

6. `AccessTheWebAsync` has run out of work that it can do without a result from `getStringTask`. `AccessTheWebAsync` next wants to calculate and return the length of the downloaded string, but the method can't calculate that value until the method has the string.

   Therefore, `AccessTheWebAsync` uses an await operator to suspend its progress and to yield control to the method that called `AccessTheWebAsync`. `AccessTheWebAsync` returns a `Task<int>` to the caller. The task represents a promise to produce an integer result that's the length of the downloaded string.

   > **NOTE**
   >
   > If `GetStringAsync` (and therefore `getStringTask`) is complete before `AccessTheWebAsync` awaits it, control remains in `AccessTheWebAsync`. The expense of suspending and then returning to `AccessTheWebAsync` would be wasted if the called asynchronous process (`getStringTask`) has already completed and `AccessTheWebSync` doesn't have to wait for the final result.

   Inside the caller (the event handler in this example), the processing pattern continues. The caller might do other work that doesn't depend on the result from `AccessTheWebAsync` before awaiting that result, or the caller might await immediately. The event handler is waiting for `AccessTheWebAsync`, and `AccessTheWebAsync` is waiting for `GetStringAsync`.

7. `GetStringAsync` completes and produces a string result. The string result isn't returned by the call to `GetStringAsync` in the way that you might expect. (Remember that the method already returned a task in step 3.) Instead, the string result is stored in the task that represents the completion of the method, `getStringTask`. The await operator retrieves the result from `getStringTask`. The assignment statement assigns the retrieved result to `urlContents`.

8. When `AccessTheWebAsync` has the string result, the method can calculate the length of the string. Then the work of `AccessTheWebAsync` is also complete, and the waiting event handler can resume. In the full example at the end of the topic, you can confirm that the event handler retrieves and prints the value of the length result.
   If you are new to asynchronous programming, take a minute to consider the difference between synchronous and asynchronous behavior. A synchronous method returns when its work is complete (step 5), but an async method returns a task value when its work is suspended (steps 3 and 6). When the async method eventually completes its work, the task is marked as completed and the result, if any, is stored in the task.

For more information about control flow, see Control Flow in Async Programs (C#).

API async methods

You might be wondering where to find methods such as `GetStringAsync` that support async programming. The .NET Framework 4.5 or higher and .NET Core contain many members that work with `async` and `await`. You can recognize them by the "Async" suffix that’s appended to the member name, and by their return type of Task or Task<TResult>. For example, the `System.IO.Stream` class contains methods such as CopyToAsync, ReadAsync, and WriteAsync alongside the synchronous methods CopyTo, Read, and Write.

The Windows Runtime also contains many methods that you can use with `async` and `await` in Windows apps. For more information, see Threading and async programming for UWP development, and Asynchronous programming (Windows Store apps) and Quickstart: Calling asynchronous APIs in C# or Visual Basic if you use earlier versions of the Windows Runtime.

Threads

Async methods are intended to be non-blocking operations. An `await` expression in an async method doesn't block the current thread while the awaited task is running. Instead, the expression signs up the rest of the method as a continuation and returns control to the caller of the async method.

The `async` and `await` keywords don't cause additional threads to be created. Async methods don't require multithreading because an async method doesn't run on its own thread. The method runs on the current synchronization context and uses time on the thread only when the method is active. You can use Task.Run to move CPU-bound work to a background thread, but a background thread doesn't help with a process that's just waiting for results to become available.

The async-based approach to asynchronous programming is preferable to existing approaches in almost every case. In particular, this approach is better than the BackgroundWorker class for I/O-bound operations because the code is simpler and you don't have to guard against race conditions. In combination with the Task.Run method, async programming is better than BackgroundWorker for CPU-bound operations because async programming separates the coordination details of running your code from the work that `Task.Run` transfers to the threadpool.

async and await

If you specify that a method is an async method by using the async modifier, you enable the following two capabilities.

- The marked async method can use await to designate suspension points. The `await` operator tells the compiler that the async method can't continue past that point until the awaited asynchronous process is complete. In the meantime, control returns to the caller of the async method.

  The suspension of an async method at an `await` expression doesn't constitute an exit from the method, and `finally` blocks don't run.

- The marked async method can itself be awaited by methods that call it.

An async method typically contains one or more occurrences of an `await` operator, but the absence of `await` expressions doesn't cause a compiler error. If an async method doesn't use an `await` operator to mark a suspension point, the method executes as a synchronous method does, despite the `async` modifier. The compiler issues a warning for such methods.

`async` and `await` are contextual keywords. For more information and examples, see the following topics:

- async
- await

Return types and parameters

An async method typically returns a Task or a Task<TResult>. Inside an async method, an `await` operator is applied to a task that's returned from a call to another async method.

You specify Task<TResult> as the return type if the method contains a return statement that specifies an operand of type `TResult`.

You use Task as the return type if the method has no return statement or has a return statement that doesn't return an operand.

Starting with C# 7.0, you can also specify any other return type, provided that the type includes a `GetAwaiter` method. ValueTask<TResult> is an example of such a type. It is available in the System.Threading.Tasks.Extension NuGet package.

The following example shows how you declare and call a method that returns a Task<TResult> or a Task.

```
// Signature specifies Task<TResult>
async Task<int> GetTaskOfTResultAsync()
{
    int hours = 0;
    await Task.Delay(0);
    // Return statement specifies an integer result.
    return hours;
}

// Calls to GetTaskOfTResultAsync
Task<int> returnedTaskTResult = GetTaskOfTResultAsync();
int intResult = await returnedTaskTResult;
// or, in a single statement
int intResult = await GetTaskOfTResultAsync();

// Signature specifies Task
async Task GetTaskAsync()
{
    await Task.Delay(0);
    // The method has no return statement.
}

// Calls to GetTaskAsync
Task returnedTask = GetTaskAsync();
await returnedTask;
// or, in a single statement
await GetTaskAsync();
```

Each returned task represents ongoing work. A task encapsulates information about the state of the asynchronous process and, eventually, either the final result from the process or the exception that the process raises if it doesn't succeed.

An async method can also have a `void` return type. This return type is used primarily to define event handlers, where a `void` return type is required. Async event handlers often serve as the starting point for async programs.

An async method that has a `void` return type can’t be awaited, and the caller of a void-returning method can't catch any exceptions that the method throws.

An async method can't declare in, ref or out parameters, but the method can call methods that have such parameters. Similarly, an async method can't return a value by reference, although it can call methods with ref return values.

For more information and examples, see Async Return Types (C#). For more information about how to catch exceptions in async methods, see try-catch.

Asynchronous APIs in Windows Runtime programming have one of the following return types, which are similar to tasks:

- IAsyncOperation<TResult>, which corresponds to Task<TResult>
- IAsyncAction, which corresponds to Task
- IAsyncActionWithProgress<TProgress>

- IAsyncOperationWithProgress<TResult, TProgress>

Naming convention

By convention, you append "Async" to the names of methods that have an `async` modifier.

You can ignore the convention where an event, base class, or interface contract suggests a different name. For example, you shouldn't rename common event handlers, such as `Button1_Click`.

Related topics and samples (Visual Studio)

TITLE	DESCRIPTION	SAMPLE
Walkthrough: Accessing the Web by Using async and await (C#)	Shows how to convert a synchronous WPF solution to an asynchronous WPF solution. The application downloads a series of websites.	Async Sample: Accessing the Web Walkthrough
How to: Extend the async Walkthrough by Using Task.WhenAll (C#)	Adds Task.WhenAll to the previous walkthrough. The use of `WhenAll` starts all the downloads at the same time.	
How to: Make Multiple Web Requests in Parallel by Using async and await (C#)	Demonstrates how to start several tasks at the same time.	Async Sample: Make Multiple Web Requests in Parallel
Async Return Types (C#)	Illustrates the types that async methods can return and explains when each type is appropriate.	
Control Flow in Async Programs (C#)	Traces in detail the flow of control through a succession of await expressions in an asynchronous program.	Async Sample: Control Flow in Async Programs
Fine-Tuning Your Async Application (C#)	Shows how to add the following functionality to your async solution: - Cancel an Async Task or a List of Tasks (C#) - Cancel Async Tasks after a Period of Time (C#) - Cancel Remaining Async Tasks after One Is Complete (C#) - Start Multiple Async Tasks and Process Them As They Complete (C#)	Async Sample: Fine Tuning Your Application
Handling Reentrancy in Async Apps (C#)	Shows how to handle cases in which an active asynchronous operation is restarted while it's running.	
WhenAny: Bridging between the .NET Framework and the Windows Runtime	Shows how to bridge between Task types in the .NET Framework and IAsyncOperations in the Windows Runtime so that you can use WhenAny with a Windows Runtime method.	Async Sample: Bridging between .NET and Windows Runtime (AsTask and WhenAny)

TITLE	DESCRIPTION	SAMPLE
Async Cancellation: Bridging between the .NET Framework and the Windows Runtime	Shows how to bridge between Task types in the .NET Framework and IAsyncOperations in the Windows Runtime so that you can use CancellationTokenSource with a Windows Runtime method.	Async Sample: Bridging between .NET and Windows Runtime (AsTask & Cancellation)
Using Async for File Access (C#)	Lists and demonstrates the benefits of using async and await to access files.	
Task-based Asynchronous Pattern (TAP)	Describes a new pattern for asynchrony in the .NET Framework. The pattern is based on the Task and Task<TResult> types.	
Async Videos on Channel 9	Provides links to a variety of videos about async programming.	

Complete example

The following code is the MainWindow.xaml.cs file from the Windows Presentation Foundation (WPF) application that this topic discusses. You can download the sample from Async Sample: Example from "Asynchronous Programming with Async and Await".

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Data;
using System.Windows.Documents;
using System.Windows.Input;
using System.Windows.Media;
using System.Windows.Media.Imaging;
using System.Windows.Navigation;
using System.Windows.Shapes;

// Add a using directive and a reference for System.Net.Http;
using System.Net.Http;

namespace AsyncFirstExample
{
    public partial class MainWindow : Window
    {
        // Mark the event handler with async so you can use await in it.
        private async void StartButton_Click(object sender, RoutedEventArgs e)
        {
            // Call and await separately.
            //Task<int> getLengthTask = AccessTheWebAsync();
            //// You can do independent work here.
            //int contentLength = await getLengthTask;

            int contentLength = await AccessTheWebAsync();

            resultsTextBox.Text +=
                $"\r\nLength of the downloaded string: {contentLength}.\r\n";
        }
        // Three things to note in the signature:
        //  - The method has an async modifier.
        //  - The return type is Task or Task<T>. (See "Return Types" section.)
        //    Here, it is Task<int> because the return statement returns an integer.
        //  - The method name ends in "Async."
        async Task<int> AccessTheWebAsync()
        {
            // You need to add a reference to System.Net.Http to declare client.
            using (HttpClient client = new HttpClient())
            {
                    // GetStringAsync returns a Task<string>. That means that when you await the
                    // task you'll get a string (urlContents).
                    Task<string> getStringTask = client.GetStringAsync("https://docs.microsoft.com");

                    // You can do work here that doesn't rely on the string from GetStringAsync.
                    DoIndependentWork();

                    // The await operator suspends AccessTheWebAsync.
                    //  - AccessTheWebAsync can't continue until getStringTask is complete.
                    //  - Meanwhile, control returns to the caller of AccessTheWebAsync.
                    //  - Control resumes here when getStringTask is complete.
                    //  - The await operator then retrieves the string result from getStringTask.
                    string urlContents = await getStringTask;

                    // The return statement specifies an integer result.
                    // Any methods that are awaiting AccessTheWebAsync retrieve the length value.
                    return urlContents.Length;
            }
        }

        void DoIndependentWork()
        {
            resultsTextBox.Text += "Working . . . . . . .\r\n";
        }
    }
}

// Sample Output:

// Working . . . . . . .

// Length of the downloaded string: 25035.
```

See also

- async
- await
- Asynchronous programming
- Async overview

Attributes (C#)

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Attributes provide a powerful method of associating metadata, or declarative information, with code (assemblies, types, methods, properties, and so forth). After an attribute is associated with a program entity, the attribute can be queried at run time by using a technique called *reflection*. For more information, see Reflection (C#).

Attributes have the following properties:

- Attributes add metadata to your program. *Metadata* is information about the types defined in a program. All .NET assemblies contain a specified set of metadata that describes the types and type members defined in the assembly. You can add custom attributes to specify any additional information that is required. For more information, see, Creating Custom Attributes (C#).
- You can apply one or more attributes to entire assemblies, modules, or smaller program elements such as classes and properties.
- Attributes can accept arguments in the same way as methods and properties.
- Your program can examine its own metadata or the metadata in other programs by using reflection. For more information, see Accessing Attributes by Using Reflection (C#).

Using attributes

Attributes can be placed on most any declaration, though a specific attribute might restrict the types of declarations on which it is valid. In C#, you specify an attribute by placing the name of the attribute enclosed in square brackets ([]) above the declaration of the entity to which it applies.

In this example, the SerializableAttribute attribute is used to apply a specific characteristic to a class:

```
[Serializable]
public class SampleClass
{
    // Objects of this type can be serialized.
}
```

A method with the attribute DllImportAttribute is declared like the following example:

```
[System.Runtime.InteropServices.DllImport("user32.dll")]
extern static void SampleMethod();
```

More than one attribute can be placed on a declaration as the following example shows:

```
using System.Runtime.InteropServices;
```

```
void MethodA([In][Out] ref double x) { }
void MethodB([Out][In] ref double x) { }
void MethodC([In, Out] ref double x) { }
```

Some attributes can be specified more than once for a given entity. An example of such a multiuse attribute is ConditionalAttribute:

```
[Conditional("DEBUG"), Conditional("TEST1")]
void TraceMethod()
{
    // ...
}
```

NOTE

By convention, all attribute names end with the word "Attribute" to distinguish them from other items in the .NET libraries. However, you do not need to specify the attribute suffix when using attributes in code. For example, `[DllImport]` is equivalent to `[DllImportAttribute]`, but `DllImportAttribute` is the attribute's actual name in the .NET Framework Class Library.

Attribute parameters

Many attributes have parameters, which can be positional, unnamed, or named. Any positional parameters must be specified in a certain order and cannot be omitted. Named parameters are optional and can be specified in any order. Positional parameters are specified first. For example, these three attributes are equivalent:

```
[DllImport("user32.dll")]
[DllImport("user32.dll", SetLastError=false, ExactSpelling=false)]
[DllImport("user32.dll", ExactSpelling=false, SetLastError=false)]
```

The first parameter, the DLL name, is positional and always comes first; the others are named. In this case, both named parameters default to false, so they can be omitted. Positional parameters correspond to the parameters of the attribute constructor. Named or optional parameters correspond to either properties or fields of the attribute. Refer to the individual attribute's documentation for information on default parameter values.

Attribute targets

The *target* of an attribute is the entity to which the attribute applies. For example, an attribute may apply to a class, a particular method, or an entire assembly. By default, an attribute applies to the element that it precedes. But you can also explicitly identify, for example, whether an attribute is applied to a method, or to its parameter, or to its return value.

To explicitly identify an attribute target, use the following syntax:

```
[target : attribute-list]
```

The list of possible `target` values is shown in the following table.

TARGET VALUE	APPLIES TO
`assembly`	Entire assembly
`module`	Current assembly module
`field`	Field in a class or a struct
`event`	Event
`method`	Method or `get` and `set` property accessors

TARGET VALUE	APPLIES TO
`param`	Method parameters or `set` property accessor parameters
`property`	Property
`return`	Return value of a method, property indexer, or `get` property accessor
`type`	Struct, class, interface, enum, or delegate

You would specify the `field` target value to apply an attribute to the backing field created for an auto-implemented property.

The following example shows how to apply attributes to assemblies and modules. For more information, see Common Attributes (C#).

```
using System;
using System.Reflection;
[assembly: AssemblyTitleAttribute("Production assembly 4")]
[module: CLSCompliant(true)]
```

The following example shows how to apply attributes to methods, method parameters, and method return values in C#.

```
// default: applies to method
[ValidatedContract]
int Method1() { return 0; }

// applies to method
[method: ValidatedContract]
int Method2() { return 0; }

// applies to return value
[return: ValidatedContract]
int Method3() { return 0; }
```

NOTE

Regardless of the targets on which `ValidatedContract` is defined to be valid, the `return` target has to be specified, even if `ValidatedContract` were defined to apply only to return values. In other words, the compiler will not use `AttributeUsage` information to resolve ambiguous attribute targets. For more information, see AttributeUsage (C#).

Common uses for attributes

The following list includes a few of the common uses of attributes in code:

- Marking methods using the `WebMethod` attribute in Web services to indicate that the method should be callable over the SOAP protocol. For more information, see WebMethodAttribute.
- Describing how to marshal method parameters when interoperating with native code. For more information, see MarshalAsAttribute.
- Describing the COM properties for classes, methods, and interfaces.
- Calling unmanaged code using the DllImportAttribute class.
- Describing your assembly in terms of title, version, description, or trademark.

- Describing which members of a class to serialize for persistence.
- Describing how to map between class members and XML nodes for XML serialization.
- Describing the security requirements for methods.
- Specifying characteristics used to enforce security.
- Controlling optimizations by the just-in-time (JIT) compiler so the code remains easy to debug.
- Obtaining information about the caller to a method.

Related sections

For more information, see:

- Creating Custom Attributes (C#)
- Accessing Attributes by Using Reflection (C#)
- How to: Create a C/C++ Union by Using Attributes (C#)
- Common Attributes (C#)
- Caller Information (C#)

See also

- C# Programming Guide
- Reflection (C#)
- Attributes
- Using Attributes in C#

Caller Information (C#)

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By using Caller Info attributes, you can obtain information about the caller to a method. You can obtain file path of the source code, the line number in the source code, and the member name of the caller. This information is helpful for tracing, debugging, and creating diagnostic tools.

To obtain this information, you use attributes that are applied to optional parameters, each of which has a default value. The following table lists the Caller Info attributes that are defined in the System.Runtime.CompilerServices namespace:

ATTRIBUTE	DESCRIPTION	TYPE
CallerFilePathAttribute	Full path of the source file that contains the caller. This is the file path at compile time.	`String`
CallerLineNumberAttribute	Line number in the source file at which the method is called.	`Integer`
CallerMemberNameAttribute	Method or property name of the caller. See Member Names later in this topic.	`String`

Example

The following example shows how to use Caller Info attributes. On each call to the `TraceMessage` method, the caller information is substituted as arguments to the optional parameters.

```
public void DoProcessing()
{
    TraceMessage("Something happened.");
}

public void TraceMessage(string message,
        [System.Runtime.CompilerServices.CallerMemberName] string memberName = "",
        [System.Runtime.CompilerServices.CallerFilePath] string sourceFilePath = "",
        [System.Runtime.CompilerServices.CallerLineNumber] int sourceLineNumber = 0)
{
    System.Diagnostics.Trace.WriteLine("message: " + message);
    System.Diagnostics.Trace.WriteLine("member name: " + memberName);
    System.Diagnostics.Trace.WriteLine("source file path: " + sourceFilePath);
    System.Diagnostics.Trace.WriteLine("source line number: " + sourceLineNumber);
}

// Sample Output:
//  message: Something happened.
//  member name: DoProcessing
//  source file path: c:\Visual Studio Projects\CallerInfoCS\CallerInfoCS\Form1.cs
//  source line number: 31
```

Remarks

You must specify an explicit default value for each optional parameter. You can't apply Caller Info attributes to parameters that aren't specified as optional.

The Caller Info attributes don't make a parameter optional. Instead, they affect the default value that's passed in when the argument is omitted.

Caller Info values are emitted as literals into the Intermediate Language (IL) at compile time. Unlike the results of the StackTrace property for exceptions, the results aren't affected by obfuscation.

You can explicitly supply the optional arguments to control the caller information or to hide caller information.

Member names

You can use the `CallerMemberName` attribute to avoid specifying the member name as a `String` argument to the called method. By using this technique, you avoid the problem that **Rename Refactoring** doesn't change the `String` values. This benefit is especially useful for the following tasks:

- Using tracing and diagnostic routines.
- Implementing the INotifyPropertyChanged interface when binding data. This interface allows the property of an object to notify a bound control that the property has changed, so that the control can display the updated information. Without the `CallerMemberName` attribute, you must specify the property name as a literal.

The following chart shows the member names that are returned when you use the `CallerMemberName` attribute.

CALLS OCCURS WITHIN	MEMBER NAME RESULT
Method, property, or event	The name of the method, property, or event from which the call originated.
Constructor	The string ".ctor"
Static constructor	The string ".cctor"
Destructor	The string "Finalize"
User-defined operators or conversions	The generated name for the member, for example, "op_Addition".
Attribute constructor	The name of the method or property to which the attribute is applied. If the attribute is any element within a member (such as a parameter, a return value, or a generic type parameter), this result is the name of the member that's associated with that element.
No containing member (for example, assembly-level or attributes that are applied to types)	The default value of the optional parameter.

See also

- Attributes (C#)
- Common Attributes (C#)
- Named and Optional Arguments
- Programming Concepts (C#)

Collections (C#)

2/3/2019 • 13 minutes to read • Edit Online

For many applications, you want to create and manage groups of related objects. There are two ways to group objects: by creating arrays of objects, and by creating collections of objects.

Arrays are most useful for creating and working with a fixed number of strongly-typed objects. For information about arrays, see Arrays.

Collections provide a more flexible way to work with groups of objects. Unlike arrays, the group of objects you work with can grow and shrink dynamically as the needs of the application change. For some collections, you can assign a key to any object that you put into the collection so that you can quickly retrieve the object by using the key.

A collection is a class, so you must declare an instance of the class before you can add elements to that collection.

If your collection contains elements of only one data type, you can use one of the classes in the System.Collections.Generic namespace. A generic collection enforces type safety so that no other data type can be added to it. When you retrieve an element from a generic collection, you do not have to determine its data type or convert it.

NOTE

For the examples in this topic, include using directives for the `System.Collections.Generic` and `System.Linq` namespaces.

In this topic

Using a Simple Collection

The examples in this section use the generic List<T> class, which enables you to work with a strongly typed list of objects.

The following example creates a list of strings and then iterates through the strings by using a foreach statement.

```
// Create a list of strings.
var salmons = new List<string>();
salmons.Add("chinook");
salmons.Add("coho");
salmons.Add("pink");
salmons.Add("sockeye");

// Iterate through the list.
foreach (var salmon in salmons)
{
    Console.Write(salmon + " ");
}
// Output: chinook coho pink sockeye
```

If the contents of a collection are known in advance, you can use a *collection initializer* to initialize the collection. For more information, see Object and Collection Initializers.

The following example is the same as the previous example, except a collection initializer is used to add elements to the collection.

```
// Create a list of strings by using a
// collection initializer.
var salmons = new List<string> { "chinook", "coho", "pink", "sockeye" };

// Iterate through the list.
foreach (var salmon in salmons)
{
    Console.Write(salmon + " ");
}
// Output: chinook coho pink sockeye
```

You can use a for statement instead of a `foreach` statement to iterate through a collection. You accomplish this by accessing the collection elements by the index position. The index of the elements starts at 0 and ends at the element count minus 1.

The following example iterates through the elements of a collection by using `for` instead of `foreach`.

```
// Create a list of strings by using a
// collection initializer.
var salmons = new List<string> { "chinook", "coho", "pink", "sockeye" };

for (var index = 0; index < salmons.Count; index++)
{
    Console.Write(salmons[index] + " ");
}
// Output: chinook coho pink sockeye
```

The following example removes an element from the collection by specifying the object to remove.

```
// Create a list of strings by using a
// collection initializer.
var salmons = new List<string> { "chinook", "coho", "pink", "sockeye" };

// Remove an element from the list by specifying
// the object.
salmons.Remove("coho");

// Iterate through the list.
foreach (var salmon in salmons)
{
    Console.Write(salmon + " ");
}
// Output: chinook pink sockeye
```

The following example removes elements from a generic list. Instead of a `foreach` statement, a for statement that iterates in descending order is used. This is because the RemoveAt method causes elements after a removed element to have a lower index value.

```
var numbers = new List<int> { 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 };

// Remove odd numbers.
for (var index = numbers.Count - 1; index >= 0; index--)
{
    if (numbers[index] % 2 == 1)
    {
        // Remove the element by specifying
        // the zero-based index in the list.
        numbers.RemoveAt(index);
    }
}

// Iterate through the list.
// A lambda expression is placed in the ForEach method
// of the List(T) object.
numbers.ForEach(
    number => Console.Write(number + " "));
// Output: 0 2 4 6 8
```

For the type of elements in the List<T>, you can also define your own class. In the following example, the `Galaxy` class that is used by the List<T> is defined in the code.

```
private static void IterateThroughList()
{
    var theGalaxies = new List<Galaxy>
        {
            new Galaxy() { Name="Tadpole", MegaLightYears=400},
            new Galaxy() { Name="Pinwheel", MegaLightYears=25},
            new Galaxy() { Name="Milky Way", MegaLightYears=0},
            new Galaxy() { Name="Andromeda", MegaLightYears=3}
        };

    foreach (Galaxy theGalaxy in theGalaxies)
    {
        Console.WriteLine(theGalaxy.Name + "  " + theGalaxy.MegaLightYears);
    }

    // Output:
    //  Tadpole  400
    //  Pinwheel  25
    //  Milky Way  0
    //  Andromeda  3
}

public class Galaxy
{
    public string Name { get; set; }
    public int MegaLightYears { get; set; }
}
```

Kinds of Collections

Many common collections are provided by the .NET Framework. Each type of collection is designed for a specific purpose.

Some of the common collection classes are described in this section:

- System.Collections.Generic classes
- System.Collections.Concurrent classes
- System.Collections classes

System.Collections.Generic Classes

You can create a generic collection by using one of the classes in the System.Collections.Generic namespace. A generic collection is useful when every item in the collection has the same data type. A generic collection enforces strong typing by allowing only the desired data type to be added.

The following table lists some of the frequently used classes of the System.Collections.Generic namespace:

CLASS	DESCRIPTION
Dictionary<TKey,TValue>	Represents a collection of key/value pairs that are organized based on the key.
List<T>	Represents a list of objects that can be accessed by index. Provides methods to search, sort, and modify lists.
Queue<T>	Represents a first in, first out (FIFO) collection of objects.
SortedList<TKey,TValue>	Represents a collection of key/value pairs that are sorted by key based on the associated IComparer<T> implementation.

CLASS	DESCRIPTION
Stack<T>	Represents a last in, first out (LIFO) collection of objects.

For additional information, see Commonly Used Collection Types, Selecting a Collection Class, and System.Collections.Generic.

System.Collections.Concurrent Classes

In the .NET Framework 4 or newer, the collections in the System.Collections.Concurrent namespace provide efficient thread-safe operations for accessing collection items from multiple threads.

The classes in the System.Collections.Concurrent namespace should be used instead of the corresponding types in the System.Collections.Generic and System.Collections namespaces whenever multiple threads are accessing the collection concurrently. For more information, see Thread-Safe Collections and System.Collections.Concurrent.

Some classes included in the System.Collections.Concurrent namespace are BlockingCollection<T>, ConcurrentDictionary<TKey,TValue>, ConcurrentQueue<T>, and ConcurrentStack<T>.

System.Collections Classes

The classes in the System.Collections namespace do not store elements as specifically typed objects, but as objects of type `Object`.

Whenever possible, you should use the generic collections in the System.Collections.Generic namespace or the System.Collections.Concurrent namespace instead of the legacy types in the `System.Collections` namespace.

The following table lists some of the frequently used classes in the `System.Collections` namespace:

CLASS	DESCRIPTION
ArrayList	Represents an array of objects whose size is dynamically increased as required.
Hashtable	Represents a collection of key/value pairs that are organized based on the hash code of the key.
Queue	Represents a first in, first out (FIFO) collection of objects.
Stack	Represents a last in, first out (LIFO) collection of objects.

The System.Collections.Specialized namespace provides specialized and strongly typed collection classes, such as string-only collections and linked-list and hybrid dictionaries.

Implementing a Collection of Key/Value Pairs

The Dictionary<TKey,TValue> generic collection enables you to access to elements in a collection by using the key of each element. Each addition to the dictionary consists of a value and its associated key. Retrieving a value by using its key is fast because the `Dictionary` class is implemented as a hash table.

The following example creates a `Dictionary` collection and iterates through the dictionary by using a `foreach` statement.

```
private static void IterateThruDictionary()
{
    Dictionary<string, Element> elements = BuildDictionary();

    foreach (KeyValuePair<string, Element> kvp in elements)
    {
        Element theElement = kvp.Value;

        Console.WriteLine("key: " + kvp.Key);
        Console.WriteLine("values: " + theElement.Symbol + " " +
            theElement.Name + " " + theElement.AtomicNumber);
    }
}

private static Dictionary<string, Element> BuildDictionary()
{
    var elements = new Dictionary<string, Element>();

    AddToDictionary(elements, "K", "Potassium", 19);
    AddToDictionary(elements, "Ca", "Calcium", 20);
    AddToDictionary(elements, "Sc", "Scandium", 21);
    AddToDictionary(elements, "Ti", "Titanium", 22);

    return elements;
}

private static void AddToDictionary(Dictionary<string, Element> elements,
    string symbol, string name, int atomicNumber)
{
    Element theElement = new Element();

    theElement.Symbol = symbol;
    theElement.Name = name;
    theElement.AtomicNumber = atomicNumber;

    elements.Add(key: theElement.Symbol, value: theElement);
}

public class Element
{
    public string Symbol { get; set; }
    public string Name { get; set; }
    public int AtomicNumber { get; set; }
}
```

To instead use a collection initializer to build the `Dictionary` collection, you can replace the `BuildDictionary` and `AddToDictionary` methods with the following method.

```
private static Dictionary<string, Element> BuildDictionary2()
{
    return new Dictionary<string, Element>
    {
        {"K",
            new Element() { Symbol="K", Name="Potassium", AtomicNumber=19}},
        {"Ca",
            new Element() { Symbol="Ca", Name="Calcium", AtomicNumber=20}},
        {"Sc",
            new Element() { Symbol="Sc", Name="Scandium", AtomicNumber=21}},
        {"Ti",
            new Element() { Symbol="Ti", Name="Titanium", AtomicNumber=22}}
    };
}
```

The following example uses the ContainsKey method and the Item[TKey] property of `Dictionary` to quickly find an item by key. The `Item` property enables you to access an item in the `elements` collection by using the `elements[symbol]` in C#.

```
private static void FindInDictionary(string symbol)
{
    Dictionary<string, Element> elements = BuildDictionary();

    if (elements.ContainsKey(symbol) == false)
    {
        Console.WriteLine(symbol + " not found");
    }
    else
    {
        Element theElement = elements[symbol];
        Console.WriteLine("found: " + theElement.Name);
    }
}
```

The following example instead uses the TryGetValue method quickly find an item by key.

```
private static void FindInDictionary2(string symbol)
{
    Dictionary<string, Element> elements = BuildDictionary();

    Element theElement = null;
    if (elements.TryGetValue(symbol, out theElement) == false)
        Console.WriteLine(symbol + " not found");
    else
        Console.WriteLine("found: " + theElement.Name);
}
```

Using LINQ to Access a Collection

LINQ (Language-Integrated Query) can be used to access collections. LINQ queries provide filtering, ordering, and grouping capabilities. For more information, see Getting Started with LINQ in C#.

The following example runs a LINQ query against a generic `List`. The LINQ query returns a different collection that contains the results.

```
private static void ShowLINQ()
{
    List<Element> elements = BuildList();

    // LINQ Query.
    var subset = from theElement in elements
                 where theElement.AtomicNumber < 22
                 orderby theElement.Name
                 select theElement;

    foreach (Element theElement in subset)
    {
        Console.WriteLine(theElement.Name + " " + theElement.AtomicNumber);
    }

    // Output:
    //  Calcium 20
    //  Potassium 19
    //  Scandium 21
}

private static List<Element> BuildList()
{
    return new List<Element>
    {
        { new Element() { Symbol="K", Name="Potassium", AtomicNumber=19}},
        { new Element() { Symbol="Ca", Name="Calcium", AtomicNumber=20}},
        { new Element() { Symbol="Sc", Name="Scandium", AtomicNumber=21}},
        { new Element() { Symbol="Ti", Name="Titanium", AtomicNumber=22}}
    };
}

public class Element
{
    public string Symbol { get; set; }
    public string Name { get; set; }
    public int AtomicNumber { get; set; }
}
```

Sorting a Collection

The following example illustrates a procedure for sorting a collection. The example sorts instances of the `Car` class that are stored in a List<T>. The `Car` class implements the IComparable<T> interface, which requires that the CompareTo method be implemented.

Each call to the CompareTo method makes a single comparison that is used for sorting. User-written code in the `CompareTo` method returns a value for each comparison of the current object with another object. The value returned is less than zero if the current object is less than the other object, greater than zero if the current object is greater than the other object, and zero if they are equal. This enables you to define in code the criteria for greater than, less than, and equal.

In the `ListCars` method, the `cars.Sort()` statement sorts the list. This call to the Sort method of the List<T> causes the `CompareTo` method to be called automatically for the `Car` objects in the `List`.

```
private static void ListCars()
{
    var cars = new List<Car>
    {
        { new Car() { Name = "car1", Color = "blue", Speed = 20}},
        { new Car() { Name = "car2", Color = "red", Speed = 50}},
        { new Car() { Name = "car3", Color = "green", Speed = 10}},
        { new Car() { Name = "car4", Color = "blue", Speed = 50}},
        { new Car() { Name = "car5", Color = "blue", Speed = 30}},
        { new Car() { Name = "car6", Color = "red", Speed = 60}},
        { new Car() { Name = "car7", Color = "green", Speed = 50}}
    };

    // Sort the cars by color alphabetically, and then by speed
    // in descending order.
    cars.Sort();

    // View all of the cars.
    foreach (Car thisCar in cars)
    {
        Console.Write(thisCar.Color.PadRight(5) + " ");
        Console.Write(thisCar.Speed.ToString() + " ");
        Console.Write(thisCar.Name);
        Console.WriteLine();
    }

    // Output:
    //  blue  50 car4
    //  blue  30 car5
    //  blue  20 car1
    //  green 50 car7
    //  green 10 car3
    //  red   60 car6
    //  red   50 car2
}

public class Car : IComparable<Car>
{
    public string Name { get; set; }
    public int Speed { get; set; }
    public string Color { get; set; }

    public int CompareTo(Car other)
    {
        // A call to this method makes a single comparison that is
        // used for sorting.

        // Determine the relative order of the objects being compared.
        // Sort by color alphabetically, and then by speed in
        // descending order.

        // Compare the colors.
        int compare;
        compare = String.Compare(this.Color, other.Color, true);

        // If the colors are the same, compare the speeds.
        if (compare == 0)
        {
            compare = this.Speed.CompareTo(other.Speed);

            // Use descending order for speed.
            compare = -compare;
        }

        return compare;
    }
}
```

Defining a Custom Collection

You can define a collection by implementing the IEnumerable<T> or IEnumerable interface.

Although you can define a custom collection, it is usually better to instead use the collections that are included in the .NET Framework, which are described in Kinds of Collections earlier in this topic.

The following example defines a custom collection class named `AllColors`. This class implements the IEnumerable interface, which requires that the GetEnumerator method be implemented.

The `GetEnumerator` method returns an instance of the `ColorEnumerator` class. `ColorEnumerator` implements the IEnumerator interface, which requires that the Current property, MoveNext method, and Reset method be implemented.

```
private static void ListColors()
{
    var colors = new AllColors();

    foreach (Color theColor in colors)
    {
        Console.Write(theColor.Name + " ");
    }
    Console.WriteLine();
    // Output: red blue green
}

// Collection class.
public class AllColors : System.Collections.IEnumerable
{
    Color[] _colors =
    {
        new Color() { Name = "red" },
        new Color() { Name = "blue" },
        new Color() { Name = "green" }
    };

    public System.Collections.IEnumerator GetEnumerator()
    {
        return new ColorEnumerator(_colors);

        // Instead of creating a custom enumerator, you could
        // use the GetEnumerator of the array.
        //return _colors.GetEnumerator();
    }

    // Custom enumerator.
    private class ColorEnumerator : System.Collections.IEnumerator
    {
        private Color[] _colors;
        private int _position = -1;

        public ColorEnumerator(Color[] colors)
        {
            _colors = colors;
        }

        object System.Collections.IEnumerator.Current
        {
            get
            {
                return _colors[_position];
            }
        }

        bool System.Collections.IEnumerator.MoveNext()
        {
            _position++;
            return (_position < _colors.Length);
        }

        void System.Collections.IEnumerator.Reset()
        {
            _position = -1;
        }
    }
}

// Element class.
public class Color
{
    public string Name { get; set; }
}
```

Iterators

An *iterator* is used to perform a custom iteration over a collection. An iterator can be a method or a `get` accessor. An iterator uses a yield return statement to return each element of the collection one at a time.

You call an iterator by using a foreach statement. Each iteration of the `foreach` loop calls the iterator. When a `yield return` statement is reached in the iterator, an expression is returned, and the current location in code is retained. Execution is restarted from that location the next time that the iterator is called.

For more information, see Iterators (C#).

The following example uses an iterator method. The iterator method has a `yield return` statement that is inside a for loop. In the `ListEvenNumbers` method, each iteration of the `foreach` statement body creates a call to the iterator method, which proceeds to the next `yield return` statement.

```
private static void ListEvenNumbers()
{
    foreach (int number in EvenSequence(5, 18))
    {
        Console.Write(number.ToString() + " ");
    }
    Console.WriteLine();
    // Output: 6 8 10 12 14 16 18
}

private static IEnumerable<int> EvenSequence(
    int firstNumber, int lastNumber)
{
    // Yield even numbers in the range.
    for (var number = firstNumber; number <= lastNumber; number++)
    {
        if (number % 2 == 0)
        {
            yield return number;
        }
    }
}
```

See also

- Object and Collection Initializers
- Programming Concepts (C#)
- Option Strict Statement
- LINQ to Objects (C#)
- Parallel LINQ (PLINQ)
- Collections and Data Structures
- Selecting a Collection Class
- Comparisons and Sorts Within Collections

- When to Use Generic Collections

Covariance and Contravariance (C#)

5/4/2018 • 3 minutes to read • Edit Online

In C#, covariance and contravariance enable implicit reference conversion for array types, delegate types, and generic type arguments. Covariance preserves assignment compatibility and contravariance reverses it.

The following code demonstrates the difference between assignment compatibility, covariance, and contravariance.

```
// Assignment compatibility.
string str = "test";
// An object of a more derived type is assigned to an object of a less derived type.
object obj = str;

// Covariance.
IEnumerable<string> strings = new List<string>();
// An object that is instantiated with a more derived type argument
// is assigned to an object instantiated with a less derived type argument.
// Assignment compatibility is preserved.
IEnumerable<object> objects = strings;

// Contravariance.
// Assume that the following method is in the class:
// static void SetObject(object o) { }
Action<object> actObject = SetObject;
// An object that is instantiated with a less derived type argument
// is assigned to an object instantiated with a more derived type argument.
// Assignment compatibility is reversed.
Action<string> actString = actObject;
```

Covariance for arrays enables implicit conversion of an array of a more derived type to an array of a less derived type. But this operation is not type safe, as shown in the following code example.

```
object[] array = new String[10];
// The following statement produces a run-time exception.
// array[0] = 10;
```

Covariance and contravariance support for method groups allows for matching method signatures with delegate types. This enables you to assign to delegates not only methods that have matching signatures, but also methods that return more derived types (covariance) or that accept parameters that have less derived types (contravariance) than that specified by the delegate type. For more information, see Variance in Delegates (C#) and Using Variance in Delegates (C#).

The following code example shows covariance and contravariance support for method groups.

```
static object GetObject() { return null; }
static void SetObject(object obj) { }

static string GetString() { return ""; }
static void SetString(string str) { }

static void Test()
{
    // Covariance. A delegate specifies a return type as object,
    // but you can assign a method that returns a string.
    Func<object> del = GetString;

    // Contravariance. A delegate specifies a parameter type as string,
    // but you can assign a method that takes an object.
    Action<string> del2 = SetObject;
}
```

In .NET Framework 4 or newer C# supports covariance and contravariance in generic interfaces and delegates and allows for implicit conversion of generic type parameters. For more information, see Variance in Generic Interfaces (C#) and Variance in Delegates (C#).

The following code example shows implicit reference conversion for generic interfaces.

```
IEnumerable<String> strings = new List<String>();
IEnumerable<Object> objects = strings;
```

A generic interface or delegate is called *variant* if its generic parameters are declared covariant or contravariant. C# enables you to create your own variant interfaces and delegates. For more information, see Creating Variant Generic Interfaces (C#) and Variance in Delegates (C#).

Related Topics

TITLE	DESCRIPTION
Variance in Generic Interfaces (C#)	Discusses covariance and contravariance in generic interfaces and provides a list of variant generic interfaces in the .NET Framework.
Creating Variant Generic Interfaces (C#)	Shows how to create custom variant interfaces.
Using Variance in Interfaces for Generic Collections (C#)	Shows how covariance and contravariance support in the IEnumerable<T> and IComparable<T> interfaces can help you reuse code.
Variance in Delegates (C#)	Discusses covariance and contravariance in generic and non-generic delegates and provides a list of variant generic delegates in the .NET Framework.
Using Variance in Delegates (C#)	Shows how to use covariance and contravariance support in non-generic delegates to match method signatures with delegate types.
Using Variance for Func and Action Generic Delegates (C#)	Shows how covariance and contravariance support in the `Func` and `Action` delegates can help you reuse code.

Expression Trees (C#)

1/23/2019 • 4 minutes to read • Edit Online

Expression trees represent code in a tree-like data structure, where each node is an expression, for example, a method call or a binary operation such as `x < y`.

You can compile and run code represented by expression trees. This enables dynamic modification of executable code, the execution of LINQ queries in various databases, and the creation of dynamic queries. For more information about expression trees in LINQ, see How to: Use Expression Trees to Build Dynamic Queries (C#).

Expression trees are also used in the dynamic language runtime (DLR) to provide interoperability between dynamic languages and the .NET Framework and to enable compiler writers to emit expression trees instead of Microsoft intermediate language (MSIL). For more information about the DLR, see Dynamic Language Runtime Overview.

You can have the C# or Visual Basic compiler create an expression tree for you based on an anonymous lambda expression, or you can create expression trees manually by using the System.Linq.Expressions namespace.

Creating Expression Trees from Lambda Expressions

When a lambda expression is assigned to a variable of type Expression<TDelegate>, the compiler emits code to build an expression tree that represents the lambda expression.

The C# compiler can generate expression trees only from expression lambdas (or single-line lambdas). It cannot parse statement lambdas (or multi-line lambdas). For more information about lambda expressions in C#, see Lambda Expressions.

The following code examples demonstrate how to have the C# compiler create an expression tree that represents the lambda expression `num => num < 5`.

```
Expression<Func<int, bool>> lambda = num => num < 5;
```

Creating Expression Trees by Using the API

To create expression trees by using the API, use the Expression class. This class contains static factory methods that create expression tree nodes of specific types, for example, ParameterExpression, which represents a variable or parameter, or MethodCallExpression, which represents a method call. ParameterExpression, MethodCallExpression, and the other expression-specific types are also defined in the System.Linq.Expressions namespace. These types derive from the abstract type Expression.

The following code example demonstrates how to create an expression tree that represents the lambda expression `num => num < 5` by using the API.

```
// Add the following using directive to your code file:
// using System.Linq.Expressions;

// Manually build the expression tree for
// the lambda expression num => num < 5.
ParameterExpression numParam = Expression.Parameter(typeof(int), "num");
ConstantExpression five = Expression.Constant(5, typeof(int));
BinaryExpression numLessThanFive = Expression.LessThan(numParam, five);
Expression<Func<int, bool>> lambda1 =
    Expression.Lambda<Func<int, bool>>(
        numLessThanFive,
        new ParameterExpression[] { numParam });
```

In .NET Framework 4 or later, the expression trees API also supports assignments and control flow expressions such as loops, conditional blocks, and `try-catch` blocks. By using the API, you can create expression trees that are more complex than those that can be created from lambda expressions by the C# compiler. The following example demonstrates how to create an expression tree that calculates the factorial of a number.

```
// Creating a parameter expression.
ParameterExpression value = Expression.Parameter(typeof(int), "value");

// Creating an expression to hold a local variable.
ParameterExpression result = Expression.Parameter(typeof(int), "result");

// Creating a label to jump to from a loop.
LabelTarget label = Expression.Label(typeof(int));

// Creating a method body.
BlockExpression block = Expression.Block(
    // Adding a local variable.
    new[] { result },
    // Assigning a constant to a local variable: result = 1
    Expression.Assign(result, Expression.Constant(1)),
    // Adding a loop.
        Expression.Loop(
    // Adding a conditional block into the loop.
           Expression.IfThenElse(
    // Condition: value > 1
               Expression.GreaterThan(value, Expression.Constant(1)),
    // If true: result *= value --
               Expression.MultiplyAssign(result,
                   Expression.PostDecrementAssign(value)),
    // If false, exit the loop and go to the label.
               Expression.Break(label, result)
           ),
    // Label to jump to.
       label
    )
);

// Compile and execute an expression tree.
int factorial = Expression.Lambda<Func<int, int>>(block, value).Compile()(5);

Console.WriteLine(factorial);
// Prints 120.
```

For more information, see Generating Dynamic Methods with Expression Trees in Visual Studio 2010, which also applies to later versions of Visual Studio.

Parsing Expression Trees

The following code example demonstrates how the expression tree that represents the lambda expression `num => num < 5` can be decomposed into its parts.

```
// Add the following using directive to your code file:
// using System.Linq.Expressions;

// Create an expression tree.
Expression<Func<int, bool>> exprTree = num => num < 5;

// Decompose the expression tree.
ParameterExpression param = (ParameterExpression)exprTree.Parameters[0];
BinaryExpression operation = (BinaryExpression)exprTree.Body;
ParameterExpression left = (ParameterExpression)operation.Left;
ConstantExpression right = (ConstantExpression)operation.Right;

Console.WriteLine("Decomposed expression: {0} => {1} {2} {3}",
                  param.Name, left.Name, operation.NodeType, right.Value);

// This code produces the following output:

// Decomposed expression: num => num LessThan 5
```

Immutability of Expression Trees

Expression trees should be immutable. This means that if you want to modify an expression tree, you must construct a new expression tree by copying the existing one and replacing nodes in it. You can use an expression tree visitor to traverse the existing expression tree. For more information, see How to: Modify Expression Trees (C#).

Compiling Expression Trees

The Expression<TDelegate> type provides the Compile method that compiles the code represented by an expression tree into an executable delegate.

The following code example demonstrates how to compile an expression tree and run the resulting code.

```
// Creating an expression tree.
Expression<Func<int, bool>> expr = num => num < 5;

// Compiling the expression tree into a delegate.
Func<int, bool> result = expr.Compile();

// Invoking the delegate and writing the result to the console.
Console.WriteLine(result(4));

// Prints True.

// You can also use simplified syntax
// to compile and run an expression tree.
// The following line can replace two previous statements.
Console.WriteLine(expr.Compile()(4));

// Also prints True.
```

For more information, see How to: Execute Expression Trees (C#).

See also

- System.Linq.Expressions
- How to: Execute Expression Trees (C#)

- How to: Modify Expression Trees (C#)
- Lambda Expressions
- Dynamic Language Runtime Overview
- Programming Concepts (C#)

Iterators (C#)

1/23/2019 • 7 minutes to read • Edit Online

An *iterator* can be used to step through collections such as lists and arrays.

An iterator method or `get` accessor performs a custom iteration over a collection. An iterator method uses the yield return statement to return each element one at a time. When a `yield return` statement is reached, the current location in code is remembered. Execution is restarted from that location the next time the iterator function is called.

You consume an iterator from client code by using a foreach statement or by using a LINQ query.

In the following example, the first iteration of the `foreach` loop causes execution to proceed in the `SomeNumbers` iterator method until the first `yield return` statement is reached. This iteration returns a value of 3, and the current location in the iterator method is retained. On the next iteration of the loop, execution in the iterator method continues from where it left off, again stopping when it reaches a `yield return` statement. This iteration returns a value of 5, and the current location in the iterator method is again retained. The loop completes when the end of the iterator method is reached.

```
static void Main()
{
    foreach (int number in SomeNumbers())
    {
        Console.Write(number.ToString() + " ");
    }
    // Output: 3 5 8
    Console.ReadKey();
}

public static System.Collections.IEnumerable SomeNumbers()
{
    yield return 3;
    yield return 5;
    yield return 8;
}
```

The return type of an iterator method or `get` accessor can be IEnumerable, IEnumerable<T>, IEnumerator, or IEnumerator<T>.

You can use a `yield break` statement to end the iteration.

NOTE

For all examples in this topic except the Simple Iterator example, include using directives for the `System.Collections` and `System.Collections.Generic` namespaces.

Simple Iterator

The following example has a single `yield return` statement that is inside a for loop. In `Main`, each iteration of the `foreach` statement body creates a call to the iterator function, which proceeds to the next `yield return` statement.

```
static void Main()
{
    foreach (int number in EvenSequence(5, 18))
    {
        Console.Write(number.ToString() + " ");
    }
    // Output: 6 8 10 12 14 16 18
    Console.ReadKey();
}

public static System.Collections.Generic.IEnumerable<int>
    EvenSequence(int firstNumber, int lastNumber)
{
    // Yield even numbers in the range.
    for (int number = firstNumber; number <= lastNumber; number++)
    {
        if (number % 2 == 0)
        {
            yield return number;
        }
    }
}
```

Creating a Collection Class

In the following example, the `DaysOfTheWeek` class implements the IEnumerable interface, which requires a GetEnumerator method. The compiler implicitly calls the `GetEnumerator` method, which returns an IEnumerator.

The `GetEnumerator` method returns each string one at a time by using the `yield return` statement.

```
static void Main()
{
    DaysOfTheWeek days = new DaysOfTheWeek();

    foreach (string day in days)
    {
        Console.Write(day + " ");
    }
    // Output: Sun Mon Tue Wed Thu Fri Sat
    Console.ReadKey();
}

public class DaysOfTheWeek : IEnumerable
{
    private string[] days = { "Sun", "Mon", "Tue", "Wed", "Thu", "Fri", "Sat" };

    public IEnumerator GetEnumerator()
    {
        for (int index = 0; index < days.Length; index++)
        {
            // Yield each day of the week.
            yield return days[index];
        }
    }
}
```

The following example creates a `Zoo` class that contains a collection of animals.

The `foreach` statement that refers to the class instance (`theZoo`) implicitly calls the `GetEnumerator` method. The `foreach` statements that refer to the `Birds` and `Mammals` properties use the `AnimalsForType` named iterator method.

```
static void Main()
{
    Zoo theZoo = new Zoo();

    theZoo.AddMammal("Whale");
    theZoo.AddMammal("Rhinoceros");
    theZoo.AddBird("Penguin");
    theZoo.AddBird("Warbler");

    foreach (string name in theZoo)
    {
        Console.Write(name + " ");
    }
    Console.WriteLine();
    // Output: Whale Rhinoceros Penguin Warbler

    foreach (string name in theZoo.Birds)
    {
        Console.Write(name + " ");
    }
    Console.WriteLine();
    // Output: Penguin Warbler

    foreach (string name in theZoo.Mammals)
    {
        Console.Write(name + " ");
    }
    Console.WriteLine();
    // Output: Whale Rhinoceros

    Console.ReadKey();
}

public class Zoo : IEnumerable
{
    // Private members.
    private List<Animal> animals = new List<Animal>();

    // Public methods.
    public void AddMammal(string name)
    {
        animals.Add(new Animal { Name = name, Type = Animal.TypeEnum.Mammal });
    }

    public void AddBird(string name)
    {
        animals.Add(new Animal { Name = name, Type = Animal.TypeEnum.Bird });
    }

    public IEnumerator GetEnumerator()
    {
        foreach (Animal theAnimal in animals)
        {
            yield return theAnimal.Name;
        }
    }

    // Public members.
    public IEnumerable Mammals
    {
        get { return AnimalsForType(Animal.TypeEnum.Mammal); }
    }

    public IEnumerable Birds
    {
        get { return AnimalsForType(Animal.TypeEnum.Bird); }
    }

    // Private methods.
    // Private methods.
    private IEnumerable AnimalsForType(Animal.TypeEnum type)
    {
        foreach (Animal theAnimal in animals)
        {
            if (theAnimal.Type == type)
            {
                yield return theAnimal.Name;
            }
        }
    }

    // Private class.
    private class Animal
    {
        public enum TypeEnum { Bird, Mammal }

        public string Name { get; set; }
        public TypeEnum Type { get; set; }
    }
}
```

Using Iterators with a Generic List

In the following example, the Stack<T> generic class implements the IEnumerable<T> generic interface. The Push method assigns values to an array of type `T`. The GetEnumerator method returns the array values by using the `yield return` statement.

In addition to the generic GetEnumerator method, the non-generic GetEnumerator method must also be implemented. This is because IEnumerable<T> inherits from IEnumerable. The non-generic implementation defers to the generic implementation.

The example uses named iterators to support various ways of iterating through the same collection of data. These named iterators are the `TopToBottom` and `BottomToTop` properties, and the `TopN` method.

The `BottomToTop` property uses an iterator in a `get` accessor.

```
static void Main()
{
    Stack<int> theStack = new Stack<int>();

    //  Add items to the stack.
    for (int number = 0; number <= 9; number++)
    {
        theStack.Push(number);
    }

    // Retrieve items from the stack.
    // foreach is allowed because theStack implements IEnumerable<int>.
    foreach (int number in theStack)
    {
        Console.Write("{0} ", number);
    }
    Console.WriteLine();
    // Output: 9 8 7 6 5 4 3 2 1 0

    // foreach is allowed, because theStack.TopToBottom returns IEnumerable(Of Integer).
    foreach (int number in theStack.TopToBottom)
    {
        Console.Write("{0} ", number);
    }
    Console.WriteLine();
    // Output: 9 8 7 6 5 4 3 2 1 0

    foreach (int number in theStack.BottomToTop)
    foreach (int number in theStack.BottomToTop)
    {
        Console.Write("{0} ", number);
    }
    Console.WriteLine();
    // Output: 0 1 2 3 4 5 6 7 8 9

    foreach (int number in theStack.TopN(7))
    {
        Console.Write("{0} ", number);
    }
    Console.WriteLine();
    // Output: 9 8 7 6 5 4 3

    Console.ReadKey();
}

public class Stack<T> : IEnumerable<T>
{
    private T[] values = new T[100];
    private int top = 0;

    public void Push(T t)
    {
        values[top] = t;
        top++;
    }
    public T Pop()
    {
        top--;
        return values[top];
    }

    // This method implements the GetEnumerator method. It allows
    // an instance of the class to be used in a foreach statement.
    public IEnumerator<T> GetEnumerator()
    {
        for (int index = top - 1; index >= 0; index--)
        {
            yield return values[index];
        }
    }

    IEnumerator IEnumerable.GetEnumerator()
    {
        return GetEnumerator();
    }

    public IEnumerable<T> TopToBottom
    {
        get { return this; }
    }

    public IEnumerable<T> BottomToTop
    {
        get
        {
            for (int index = 0; index <= top - 1; index++)
            {
                yield return values[index];
            }
        }
    }

    public IEnumerable<T> TopN(int itemsFromTop)
    {
        // Return less than itemsFromTop if necessary.
        int startIndex = itemsFromTop >= top ? 0 : top - itemsFromTop;

        for (int index = top - 1; index >= startIndex; index--)
```

```
            for (int index = top - 1; index >= startIndex; index--)
            {
                yield return values[index];
            }
        }

    }
```

Syntax Information

An iterator can occur as a method or `get` accessor. An iterator cannot occur in an event, instance constructor, static constructor, or static finalizer.

An implicit conversion must exist from the expression type in the `yield return` statement to the type argument for the IEnumerable returned by the iterator.

In C#, an iterator method cannot have any `in`, `ref`, or `out` parameters.

In C#, "yield" is not a reserved word and has special meaning only when it is used before a `return` or `break` keyword.

Technical Implementation

Although you write an iterator as a method, the compiler translates it into a nested class that is, in effect, a state machine. This class keeps track of the position of the iterator as long the `foreach` loop in the client code continues.

To see what the compiler does, you can use the Ildasm.exe tool to view the Microsoft intermediate language code that's generated for an iterator method.

When you create an iterator for a class or struct, you don't have to implement the whole IEnumerator interface. When the compiler detects the iterator, it automatically generates the `Current`, `MoveNext`, and `Dispose` methods of the IEnumerator or IEnumerator<T> interface.

On each successive iteration of the `foreach` loop (or the direct call to `IEnumerator.MoveNext`), the next iterator code body resumes after the previous `yield return` statement. It then continues to the next `yield return` statement until the end of the iterator body is reached, or until a `yield break` statement is encountered.

Iterators don't support the IEnumerator.Reset method. To reiterate from the start, you must obtain a new iterator. Calling Reset on the iterator returned by an iterator method throws a NotSupportedException.

For additional information, see the C# Language Specification.

Use of Iterators

Iterators enable you to maintain the simplicity of a `foreach` loop when you need to use complex code to populate a list sequence. This can be useful when you want to do the following:

- Modify the list sequence after the first `foreach` loop iteration.
- Avoid fully loading a large list before the first iteration of a `foreach` loop. An example is a paged fetch to load a batch of table rows. Another example is the EnumerateFiles method, which implements iterators within the .NET Framework.
- Encapsulate building the list in the iterator. In the iterator method, you can build the list and then yield each result in a loop.

See also

- System.Collections.Generic
- IEnumerable<T>
- foreach, in
- yield
- Using foreach with Arrays
- Generics

Language Integrated Query (LINQ)

10/13/2018 • 3 minutes to read • Edit Online

Language-Integrated Query (LINQ) is the name for a set of technologies based on the integration of query capabilities directly into the C# language. Traditionally, queries against data are expressed as simple strings without type checking at compile time or IntelliSense support. Furthermore, you have to learn a different query language for each type of data source: SQL databases, XML documents, various Web services, and so on. With LINQ, a query is a first-class language construct, just like classes, methods, events.

For a developer who writes queries, the most visible "language-integrated" part of LINQ is the query expression. Query expressions are written in a declarative *query syntax*. By using query syntax, you can perform filtering, ordering, and grouping operations on data sources with a minimum of code. You use the same basic query expression patterns to query and transform data in SQL databases, ADO .NET Datasets, XML documents and streams, and .NET collections.

The following example shows the complete query operation. The complete operation includes creating a data source, defining the query expression, and executing the query in a `foreach` statement.

```
class LINQQueryExpressions
{
    static void Main()
    {

        // Specify the data source.
        int[] scores = new int[] { 97, 92, 81, 60 };

        // Define the query expression.
        IEnumerable<int> scoreQuery =
            from score in scores
            where score > 80
            select score;

        // Execute the query.
        foreach (int i in scoreQuery)
        {
            Console.Write(i + " ");
        }
    }
}
// Output: 97 92 81
```

Query expression overview

- Query expressions can be used to query and to transform data from any LINQ-enabled data source. For example, a single query can retrieve data from a SQL database, and produce an XML stream as output.
- Query expressions are easy to master because they use many familiar C# language constructs.
- The variables in a query expression are all strongly typed, although in many cases you do not have to provide the type explicitly because the compiler can infer it. For more information, see Type relationships in LINQ query operations.
- A query is not executed until you iterate over the query variable, for example, in a `foreach` statement. For more information, see Introduction to LINQ queries.

- At compile time, query expressions are converted to Standard Query Operator method calls according to the rules set forth in the C# specification. Any query that can be expressed by using query syntax can also be expressed by using method syntax. However, in most cases query syntax is more readable and concise. For more information, see C# language specification and Standard query operators overview.
- As a rule when you write LINQ queries, we recommend that you use query syntax whenever possible and method syntax whenever necessary. There is no semantic or performance difference between the two different forms. Query expressions are often more readable than equivalent expressions written in method syntax.
- Some query operations, such as Count or Max, have no equivalent query expression clause and must therefore be expressed as a method call. Method syntax can be combined with query syntax in various ways. For more information, see Query syntax and method syntax in LINQ.
- Query expressions can be compiled to expression trees or to delegates, depending on the type that the query is applied to. IEnumerable<T> queries are compiled to delegates. IQueryable and IQueryable<T> queries are compiled to expression trees. For more information, see Expression trees.

Next steps

To learn more details about LINQ, start by becoming familiar with some basic concepts in Query expression basics, and then read the documentation for the LINQ technology in which you are interested:

- XML documents: LINQ to XML
- ADO.NET Entity Framework: LINQ to entities
- .NET collections, files, strings and so on: LINQ to objects

To gain a deeper understanding of LINQ in general, see LINQ in C#.

To start working with LINQ in C#, see the tutorial Working with LINQ.

Object-Oriented Programming (C#)

1/23/2019 • 9 minutes to read • Edit Online

C# provides full support for object-oriented programming including encapsulation, inheritance, and polymorphism.

Encapsulation means that a group of related properties, methods, and other members are treated as a single unit or object.

Inheritance describes the ability to create new classes based on an existing class.

Polymorphism means that you can have multiple classes that can be used interchangeably, even though each class implements the same properties or methods in different ways.

This section describes the following concepts:

Classes and Objects

The terms *class* and *object* are sometimes used interchangeably, but in fact, classes describe the *type* of objects, while objects are usable *instances* of classes. So, the act of creating an object is called *instantiation*. Using the blueprint analogy, a class is a blueprint, and an object is a building made from that blueprint.

To define a class:

```
class SampleClass
{
}
```

C# also provides a light version of classes called *structures* that are useful when you need to create large array of objects and do not want to consume too much memory for that.

To define a structure:

```
struct SampleStruct
{
}
```

For more information, see:

- class
- struct

Class Members

Each class can have different *class members* that include properties that describe class data, methods that define class behavior, and events that provide communication between different classes and objects.

Properties and Fields

Fields and properties represent information that an object contains. Fields are like variables because they can be read or set directly.

To define a field:

```
class SampleClass
{
    public string sampleField;
}
```

Properties have get and set procedures, which provide more control on how values are set or returned.

C# allows you either to create a private field for storing the property value or use so-called auto-implemented properties that create this field automatically behind the scenes and provide the basic logic for the property procedures.

To define an auto-implemented property:

```
class SampleClass
{
    public int SampleProperty { get; set; }
}
```

If you need to perform some additional operations for reading and writing the property value, define a field for storing the property value and provide the basic logic for storing and retrieving it:

```
class SampleClass
{
    private int _sample;
    public int Sample
    {
        // Return the value stored in a field.
        get { return _sample; }
        // Store the value in the field.
        set { _sample = value; }
    }
}
```

Most properties have methods or procedures to both set and get the property value. However, you can create read-only or write-only properties to restrict them from being modified or read. In C#, you can omit the `get` or `set` property method. However, auto-implemented properties cannot be read-only or write-only.

For more information, see:

- get
- set

Methods

A *method* is an action that an object can perform.

To define a method of a class:

```
class SampleClass
{
    public int sampleMethod(string sampleParam)
    {
        // Insert code here
    }
}
```

A class can have several implementations, or *overloads*, of the same method that differ in the number of parameters or parameter types.

To overload a method:

```
public int sampleMethod(string sampleParam) {};
public int sampleMethod(int sampleParam) {}
```

In most cases you declare a method within a class definition. However, C# also supports *extension methods* that allow you to add methods to an existing class outside the actual definition of the class.

For more information, see:

- Methods
- Extension Methods

Constructors

Constructors are class methods that are executed automatically when an object of a given type is created. Constructors usually initialize the data members of the new object. A constructor can run only once when a class is created. Furthermore, the code in the constructor always runs before any other code in a class. However, you can create multiple constructor overloads in the same way as for any other method.

To define a constructor for a class:

```
public class SampleClass
{
    public SampleClass()
    {
        // Add code here
    }
}
```

For more information, see:

Constructors.

Finalizers

Finalizers are used to destruct instances of classes. In the .NET Framework, the garbage collector automatically manages the allocation and release of memory for the managed objects in your application. However, you may still need finalizers to clean up any unmanaged resources that your application creates. There can be only one finalizers for a class.

For more information about finalizers and garbage collection in the .NET Framework, see Garbage Collection.

Events

Events enable a class or object to notify other classes or objects when something of interest occurs. The class that sends (or raises) the event is called the *publisher* and the classes that receive (or handle) the event are called *subscribers*. For more information about events, how they are raised and handled, see Events.

- To declare an event in a class, use the event keyword.
- To raise an event, invoke the event delegate.
- To subscribe to an event, use the `+=` operator; to unsubscribe from an event, use the `-=` operator.

Nested Classes

A class defined within another class is called *nested*. By default, the nested class is private.

```
class Container
{
    class Nested
    {
        // Add code here.
    }
}
```

To create an instance of the nested class, use the name of the container class followed by the dot and then followed by the name of the nested class:

```
Container.Nested nestedInstance = new Container.Nested()
```

Access Modifiers and Access Levels

All classes and class members can specify what access level they provide to other classes by using *access modifiers*.

The following access modifiers are available:

C# MODIFIER	DEFINITION
public	The type or member can be accessed by any other code in the same assembly or another assembly that references it.

C# MODIFIER	DEFINITION
private	The type or member can only be accessed by code in the same class.
protected	The type or member can only be accessed by code in the same class or in a derived class.
internal	The type or member can be accessed by any code in the same assembly, but not from another assembly.
protected internal	The type or member can be accessed by any code in the same assembly, or by any derived class in another assembly.
private protected	The type or member can be accessed by code in the same class or in a derived class within the base class assembly.

For more information, see Access Modifiers.

Instantiating Classes

To create an object, you need to instantiate a class, or create a class instance.

```
SampleClass sampleObject = new SampleClass();
```

After instantiating a class, you can assign values to the instance's properties and fields and invoke class methods.

```
// Set a property value.
sampleObject.sampleProperty = "Sample String";
// Call a method.
sampleObject.sampleMethod();
```

To assign values to properties during the class instantiation process, use object initializers:

```
// Set a property value.
SampleClass sampleObject = new SampleClass
    { FirstProperty = "A", SecondProperty = "B" };
```

For more information, see:

- new Operator
- Object and Collection Initializers

Static Classes and Members

A static member of the class is a property, procedure, or field that is shared by all instances of a class.

To define a static member:

```
static class SampleClass
{
    public static string SampleString = "Sample String";
}
```

To access the static member, use the name of the class without creating an object of this class:

```
Console.WriteLine(SampleClass.SampleString);
```

Static classes in C# have static members only and cannot be instantiated. Static members also cannot access non-static properties, fields or methods

For more information, see: static.

Anonymous Types

Anonymous types enable you to create objects without writing a class definition for the data type. Instead, the compiler generates a class for you. The class has no usable name and contains the properties you specify in declaring the object.

To create an instance of an anonymous type:

```
// sampleObject is an instance of a simple anonymous type.
var sampleObject =
    new { FirstProperty = "A", SecondProperty = "B" };
```

For more information, see: Anonymous Types.

Inheritance

Inheritance enables you to create a new class that reuses, extends, and modifies the behavior that is defined in another class. The class whose members are inherited is called the *base class*, and the class that inherits those members is called the *derived class*. However, all classes in C# implicitly inherit from the Object class that supports .NET class hierarchy and provides low-level services to all classes.

NOTE

C# doesn't support multiple inheritance. That is, you can specify only one base class for a derived class.

To inherit from a base class:

```
class DerivedClass:BaseClass {}
```

By default all classes can be inherited. However, you can specify whether a class must not be used as a base class, or create a class that can be used as a base class only.

To specify that a class cannot be used as a base class:

```
public sealed class A { }
```

To specify that a class can be used as a base class only and cannot be instantiated:

```
public abstract class B { }
```

For more information, see:

- sealed
- abstract

Overriding Members

By default, a derived class inherits all members from its base class. If you want to change the behavior of the inherited member, you need to override it. That is, you can define a new implementation of the method, property or event in the derived class.

The following modifiers are used to control how properties and methods are overridden:

C# MODIFIER	DEFINITION
virtual	Allows a class member to be overridden in a derived class.
override	Overrides a virtual (overridable) member defined in the base class.
abstract	Requires that a class member to be overridden in the derived class.
new Modifier	Hides a member inherited from a base class

Interfaces

Interfaces, like classes, define a set of properties, methods, and events. But unlike classes, interfaces do not provide implementation. They are implemented by classes, and defined as separate entities from classes. An interface represents a contract, in that a class that implements an interface must implement every aspect of that interface exactly as it is defined.

To define an interface:

```
interface ISampleInterface
{
    void doSomething();
}
```

To implement an interface in a class:

```
class SampleClass : ISampleInterface
{
    void ISampleInterface.doSomething()
    {
        // Method implementation.
    }
}
```

For more information, see:

Interfaces

interface

Generics

Classes, structures, interfaces and methods in the .NET Framework can include *type parameters* that define types of objects that they can store or use. The most common example of generics is a collection, where you can specify the type of objects to be stored in a collection.

To define a generic class:

```
public class SampleGeneric<T>
{
    public T Field;
}
```

To create an instance of a generic class:

```
SampleGeneric<string> sampleObject = new SampleGeneric<string>();
sampleObject.Field = "Sample string";
```

For more information, see:

- Generics
- Generics

Delegates

A *delegate* is a type that defines a method signature, and can provide a reference to any method with a compatible signature. You can invoke (or call) the method through the delegate. Delegates are used to pass methods as arguments to other methods.

> **NOTE**
>
> Event handlers are nothing more than methods that are invoked through delegates. For more information about using delegates in event handling, see Events.

To create a delegate:

```
public delegate void SampleDelegate(string str);
```

To create a reference to a method that matches the signature specified by the delegate:

```
class SampleClass
{
    // Method that matches the SampleDelegate signature.
    public static void sampleMethod(string message)
    {
        // Add code here.
    }
    // Method that instantiates the delegate.
    void SampleDelegate()
    {
        SampleDelegate sd = sampleMethod;
        sd("Sample string");
    }
}
```

For more information, see:

- Delegates
- delegate

See also

- C# Programming Guide

Reflection (C#)

1/23/2019 • 2 minutes to read • Edit Online

Reflection provides objects (of type Type) that describe assemblies, modules and types. 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 and invoke its methods or access its fields and properties. If you are using attributes in your code, reflection enables you to access them. For more information, see Attributes.

Here's a simple example of reflection using the static method `GetType` - inherited by all types from the `Object` base class - to obtain the type of a variable:

```
// Using GetType to obtain type information:
int i = 42;
System.Type type = i.GetType();
System.Console.WriteLine(type);
```

The output is:

```
System.Int32
```

The following example uses reflection to obtain the full name of the loaded assembly.

```
// Using Reflection to get information from an Assembly:
System.Reflection.Assembly info = typeof(System.Int32).Assembly;
System.Console.WriteLine(info);
```

The output is:

```
mscorlib, Version=2.0.0.0, Culture=neutral, PublicKeyToken=b77a5c561934e089
```

NOTE

The C# keywords `protected` and `internal` have no meaning in IL and are not used in the reflection APIs. The corresponding terms in IL are *Family* and *Assembly*. To identify an `internal` method using reflection, use the IsAssembly property. To identify a `protected internal` method, use the IsFamilyOrAssembly.

Reflection Overview

Reflection is useful in the following situations:

- When you have to access attributes in your program's metadata. For more information, see Retrieving Information Stored in Attributes.
- For examining and instantiating types in an assembly.
- For building new types at runtime. Use classes in System.Reflection.Emit.
- For performing late binding, accessing methods on types created at run time. See the topic Dynamically Loading and Using Types.

Related Sections

For more information:

- Reflection
- Viewing Type Information
- Reflection and Generic Types
- System.Reflection.Emit
- Retrieving Information Stored in Attributes

See also

- C# Programming Guide
- Assemblies in the Common Language Runtime

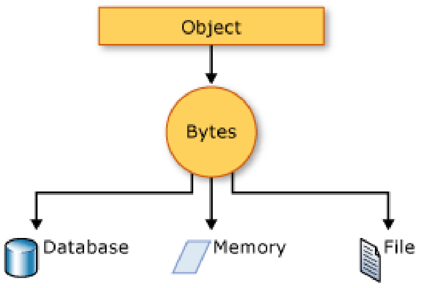
Serialization (C#)

9/5/2018 • 3 minutes to read • Edit Online

Serialization is the process of converting an object into a stream of bytes to store the object or transmit it to memory, a database, or a file. Its main purpose is to save the state of an object in order to be able to recreate it when needed. The reverse process is called deserialization.

How serialization works

This illustration shows the overall process of serialization.



The object is serialized to a stream, which carries not just the data, but information about the object's type, such as its version, culture, and assembly name. From that stream, it can be stored in a database, a file, or memory.

Uses for serialization

Serialization allows the developer to save the state of an object and recreate it as needed, providing storage of objects as well as data exchange. Through serialization, a developer can perform actions like sending the object to a remote application by means of a Web Service, passing an object from one domain to another, passing an object through a firewall as an XML string, or maintaining security or user-specific information across applications.

Making an object serializable

To serialize an object, you need the object to be serialized, a stream to contain the serialized object, and a Formatter. System.Runtime.Serialization contains the classes necessary for serializing and deserializing objects.

Apply the SerializableAttribute attribute to a type to indicate that instances of this type can be serialized. An exception is thrown if you attempt to serialize but the type doesn't have the SerializableAttribute attribute.

If you don't want a field within your class to be serializable, apply the NonSerializedAttribute attribute. If a field of a serializable type contains a pointer, a handle, or some other data structure that is specific to a particular environment, and the field cannot be meaningfully reconstituted in a different environment, then you may want to make it nonserializable.

If a serialized class contains references to objects of other classes that are marked SerializableAttribute, those objects will also be serialized.

Binary and XML serialization

You can use binary or XML serialization. In binary serialization, all members, even members that are read-only, are serialized, and performance is enhanced. XML serialization provides more readable code, and greater flexibility of object sharing and usage for interoperability purposes.

Binary serialization

Binary serialization uses binary encoding to produce compact serialization for uses such as storage or socketbased network streams.

XML serialization

XML serialization serializes the public fields and properties of an object, or the parameters and return values of methods, into an XML stream that conforms to a specific XML Schema definition language (XSD) document. XML serialization results in strongly typed classes with public properties and fields that are converted to XML. System.Xml.Serialization contains the classes necessary for serializing and deserializing XML.

You apply attributes to classes and class members to control the way the XmlSerializer serializes or deserializes an instance of the class.

Basic and custom serialization

Serialization can be performed in two ways, basic and custom. Basic serialization uses the .NET Framework to automatically serialize the object.

Basic serialization

The only requirement in basic serialization is that the object has the SerializableAttribute attribute applied. The NonSerializedAttribute can be used to keep specific fields from being serialized.

When you use basic serialization, the versioning of objects may create problems. You would use custom serialization when versioning issues are important. Basic serialization is the easiest way to perform serialization, but it does not provide much control over the process.

Custom serialization

In custom serialization, you can specify exactly which objects will be serialized and how it will be done. The class must be marked SerializableAttribute and implement the ISerializable interface.

If you want your object to be deserialized in a custom manner as well, you must use a custom constructor.

Designer serialization

Designer serialization is a special form of serialization that involves the kind of object persistence associated with development tools. Designer serialization is the process of converting an object graph into a source file that can later be used to recover the object graph. A source file can contain code, markup, or even SQL table information.

Related Topics and Examples

Walkthrough: Persisting an Object in Visual Studio (C#)
Demonstrates how serialization can be used to persist an object's data between instances, allowing you to store values and retrieve them the next time the object is instantiated.

How to: Read Object Data from an XML File (C#)
Shows how to read object data that was previously written to an XML file using the XmlSerializer class.

How to: Write Object Data to an XML File (C#)
Shows how to write the object from a class to an XML file using the XmlSerializer class.