

Beginning XML with C# 7

XML Processing and Data Access for
C# Developers

Second Edition

Bipin Joshi



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Data Access for C# Developers

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ISBN-13 (pbk): 978-1-4842-3104-3
<https://doi.org/10.1007/978-1-4842-3105-0>

ISBN-13 (electronic): 978-1-4842-3105-0

Library of Congress Control Number: 2017961825

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*This work is dedicated to Lord Shiva, who, I believe,
resides in each one of us as pure consciousness.*

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About the Author

Bipin Joshi is a software consultant, trainer, author, and yoga mentor who writes about seemingly unrelated topics: software development and yoga! He conducts online training courses to help developers learn ASP.NET and web technologies better and faster. Currently his focus is ASP.NET, ASP.NET Core, C#, JavaScript frameworks, and design/architectural patterns. More details about his training courses are available at <http://www.binaryintellect.com>.

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About the Technical Reviewer



Michael Thomas has worked in software development for more than 20 years as an individual contributor, team lead, program manager, and vice president of engineering. Michael has more than 10 years of experience working with mobile devices. His current focus is in the medical sector, using mobile devices to accelerate information transfer between patients and health care providers.

Introduction

The Internet has brought a huge difference in the way we develop and use software applications. Applications have become more complex and distributed, connecting heterogeneous systems.

With such a radical change, the role of XML is highly significant. XML has already established itself as a standard way of data encoding and transfer. In spite of the popularity of formats such as JSON (JavaScript Object Notation), XML is still being used in a wide range of applications, including enterprise applications. XML comes with a family of technologies such as XSLT, XPath, and XSD, that provide a fuller support for transforming, querying, and validating the underlying data.

No wonder that Microsoft's .NET Framework provides such a strong support for XML. Data access, raw parsing, serialization, configuration, code documentation, and services are some of the examples where the .NET Framework harnesses the power and flexibility of XML.

The .NET Framework comes with a plethora of classes that allow you to work with XML data. This book demystifies XML and allied technologies. Reading and writing XML data, using DOM, ADO.NET integration with XML, SQL Server XML features, applying XSLT style sheets, SOAP, use of XML in services (ASMX/WCF/Web API), and configuration systems are some of the topics that this book explores in detail. Neat and concise examples scattered throughout the book will help you understand the practical use of the topic under consideration. The book can also act as a handy reference when developers go on the job.

Who Is This Book For?

This book is for developers who are familiar with the .NET Framework and want to dive deep into the XML features of .NET. This book will not teach you XML manipulation using non-Microsoft tools. All the examples in this book are presented in C#, and hence working knowledge of C# is assumed. In some chapters, familiarity with LINQ, ADO.NET, and SQL Server is necessary, although I have provided a brief overview along with the respective topics.

Software Required

In order to work with the examples presented in this book, you need the following software:

- *Visual Studio 2017:* I used the Professional Edition of the product but for most of the examples you can also use the Community Edition.
- *.NET Framework 4.7 and C# 7:* I used .NET Framework 4.7 to build the examples discussed in this book. The examples and code fragments are written using C# 7.
- *SQL Server with Northwind sample database:* In the examples that rely on a database, I used SQL Server 2012 Developer Edition. You may also use some later version of the product if you so wish. Throughout the book we use data from the Northwind sample database. So, you need it ready in the SQL Server. You can download the required scripts from Microsoft's official web site.

- *SQLXML 4.0 SPI*: In the examples that discuss SQLXML programming, you need SQLXML 4.0 SP1 installed on your machine. It can be downloaded from Microsoft's official web site.
- *Sandcastle Help File Builder (SHFB)*: In the examples that discuss XML code commenting, you need SHFB to generate the documentation. You can download it from its GitHub page.
- *Browser*: In the examples that require a web browser, I used Firefox. But any other browser should also work.

Structure of This Book

The book is divided into 13 chapters and two appendices.

Chapters 1 to 4 talk about navigating, reading, and writing XML documents by using classes from the `System.Xml` namespace. In these chapters, you learn to use classes such as `XmlDocument`, `XmlReader`, `XmlWriter`, and `XPathNavigator`.

Manipulating XML data is just one part of the story. Often you need to validate and transform it so that it becomes acceptable to your system. Chapters 5 and 6 deal with XML document validation and XSLT transformations, respectively.

The .NET Framework technologies themselves use XML in many ways. This is often under the hood, but for any XML developer, knowing where this occurs is essential. To that end, Chapters 7 to 10 cover topics such as ADO.NET integration with XML, XML serialization, and ASMX/WCF/Web API services.

Microsoft has not limited the use of XML only to areas such as ADO.NET, serialization, and services. SQL Server incorporates many XML-related features. These features are discussed in Chapter 11. Although this topic isn't strictly one of the XML features of .NET Framework, many developers will find it useful, because many real-world projects developed using the .NET Framework use SQL Server as a datastore.

Chapter 12 covers many other areas where the .NET Framework uses XML. Some of them include XAML, ASP.NET server controls, XML configuration files, and XML comments.

Language Integrated Query (LINQ) includes what is known as LINQ to XML. It can be used to handle XML data in LINQ-style. Chapter 13 is dedicated to this programming model. Here, you will learn about core LINQ to XML features, including parsing and loading XML trees the LINQ to XML way and validating and projecting XML data.

Finally, the two appendices supplement what you learned throughout the book by providing some more information and resources.

Downloading the Source Code

The complete source code for the book is available for download at the book's companion web site. Visit www.apress.com and go to this book's information page. You can then download the source code from the Source Code/Downloads section.

Contacting the Author

You can reach me via my web site at <http://www.binaryintellect.net>. You can also follow me on various social networking sites (visit my web site for the links).

CHAPTER 1



Introducing XML and the .NET Framework

Over the years XML has emerged as one of the most important standards for data representation and transportation. No wonder that Microsoft has embraced it fully in the .NET Framework. This chapter provides an overview of what XML is and how it is related to the .NET Framework. Many of the topics discussed in this chapter might be already familiar to you. Nevertheless, I will cover them briefly here so as to form a common platform for further chapters. Specifically, this chapter covers the following:

- Features and benefits of XML
- Rules of XML grammar
- Brief introduction to allied technologies such as DTD, XML Schema, parsers, XSLT, and XPath
- Overview of the .NET Framework
- Use of XML in the .NET Framework
- Introduction to Visual Studio

If you find these concepts highly familiar, you may want to skip ahead to Chapter 2.

What Is XML?

XML stands for *Extensible Markup Language* and is a markup language used to describe data. It offers a standardized way to represent textual data. Often the XML data is also referred to as an XML document. The XML data doesn't perform anything on its own; to process that data, you need to use a piece of software called a *parser*. Unlike Hypertext Markup Language (HTML), which focuses on how to present data, XML focuses on how to represent data. XML consists of user-defined tags, which means you are free to define and use your own tags in an XML document.

XML was approved as a recommendation by the World Wide Web Consortium (W3C) in February 1998. Naturally, this very fact contributed a lot to such a wide acceptance and support for XML in the software industry.

Now that you have brief idea about XML, let's see a simple XML document, as illustrated in Listing 1-1.

Listing 1-1. A Simple XML Document

```
<?xml version="1.0" encoding="utf-8" ?>
<customers>
  <customer ID="C001">
    <name>Nancy Davolio</name>
    <email>nancy@localhost</email>
    <comments>
      <![CDATA[Regular customer since 1995]]>
    </comments>
  </customer>
  <customer ID="C002">
    <name>Steven Buchanan</name>
    <email>steven@localhost</email>
    <comments>
      <![CDATA[New customer interested in multiple services]]>
    </comments>
  </customer>
</customers>
```

Many rules govern the creation of such XML documents. But we will save them for later discussion.

Benefits of XML

Why did XML become so popular? Well, this question has many answers, and I will present some of the important ones in this section.

XML Is an Industry Standard

As you learned previously, XML is a W3C recommendation. This means it is an industry standard governed by a vendor-independent body. History shows that vendor-specific proprietary standards don't get massive acceptance in the software industry. This non-acceptance affects overall cross-platform data sharing and integration. Being an industry standard has helped XML gain huge acceptance.

XML Is Self-Describing

XML documents are self-describing. Because of markup tags, they are more readable than, say, comma-separated values (CSV) files.

XML Is Extensible

Markup languages such as HTML have a fixed set of tags and attributes—you cannot add your own tags. XML, on the other hand, allows you to define your own markup tags.

XML Can Be Processed Easily

Traditionally, the CSV format was a common way to represent and transport data. However, to process such data, you need to know the exact location of the commas (,) or any other delimiter used. This makes reading and writing the document difficult. The problem becomes severe when you are dealing with a number of altogether different and unknown CSV files.

As I said earlier, XML documents can be processed by a piece of software called a parser. Because XML documents use markup tags, a parser can read them easily. Parsers are discussed in more detail later in this chapter.

XML Can Be Used to Easily Exchange Data

Integrating cross-platform and cross-vendor applications is always difficult and challenging. Exchanging data in heterogeneous systems is a key problem in such applications. Using XML as a data-exchange format makes your life easy. XML is an industry standard, so it has massive support, and almost all vendors support it in one way or another.

XML Can Be Used to Easily Share Data

The fact that XML is nothing but textual data ensures that it can be shared among heterogeneous systems. For example, how can the data generated by a Windows Forms application running on a Windows machine be accessible in a Java application running on a Unix box? XML is the answer.

XML Can Be Used to Create Specialized Vocabularies

As you already know, XML is an extensible standard. By using XML as a base, you can create your own vocabularies. Wireless Application Protocol (WAP), Wireless Markup Language (WML), and Simple Object Access Protocol (SOAP) are some examples of specialized XML vocabularies.

XML-Driven Applications

Now that you know the features and benefits of XML, let's see what all these benefits mean to modern software systems.

Figure 1-1 shows a traditional web-based application. The application consists of ASP.NET pages hosted on a web server. The client, in the form of a web browser, requests various web pages. On receiving the requests, the web server processes them and sends the response in the form of HTML content. This architecture sounds good at first glance, but suffers from several shortcomings:

- It considers only web browsers as clients.
- The response from the web server is always in HTML. That means a desktop-based application may not render this response at all.
- The data and presentation logic are tightly coupled. If we want to change the presentation of the same data, we need to make considerable changes.
- Tomorrow, if some other application wants to consume the same data, it cannot be shared easily.

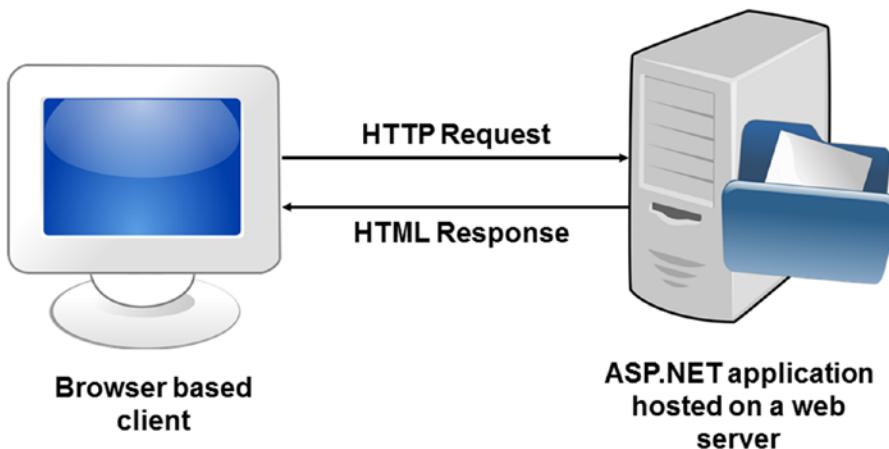


Figure 1-1. Classic architecture for developing applications

Now, let's see how XML can come to the rescue in such situations.

Note For the sake of easy understanding the example discussed here is deliberately kept very simple and straightforward. In a more realistic case there could be one or more services involved that return the XML data. The applications then consume those services as and when required. You will learn how XML and services are related in later chapters.

Have a look at Figure 1-2, where there are multiple types of clients. One is a web browser, and the other is a desktop application. Both send requests to the server along with XML data (if any). The server processes the requests and sends back the data in XML format. The web browser applies a style sheet (discussed later) to the XML data to transform it into HTML markup. The desktop application, on the other hand, parses the data by using an XML parser (discussed later) and displays it in a grid. Much more flexible than the previous architecture, isn't it? The advantages of the new architecture are as follows:

- The application has multiple types of clients. It is not tied only to web browsers.
- There is loose coupling between the client and the processing logic.
- New types of clients can be added at any time without changing the processing logic on the server.
- The data and the presentation logic are neatly separated from each other. Web clients have one set of presentation logic, whereas desktop applications have their own presentation logic.
- Data sharing becomes easy, because the outputted data is in XML format.

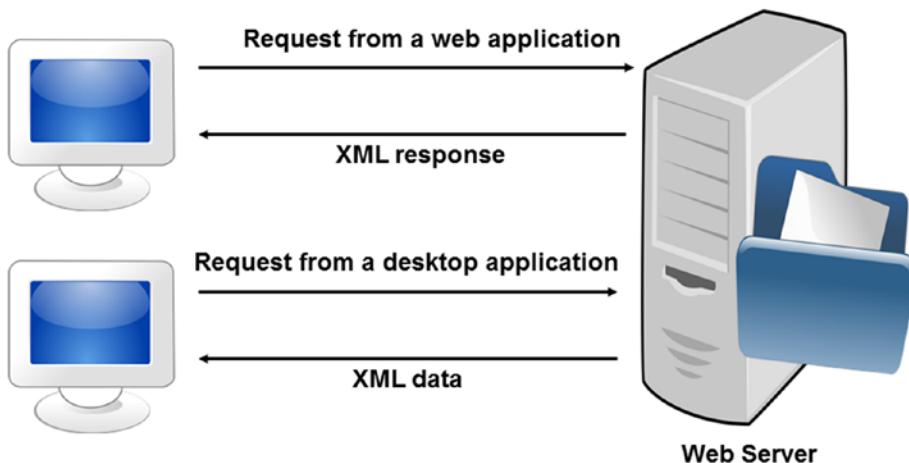


Figure 1-2. XML-driven architecture

Rules of XML Grammar

In the “What Is XML?” section, you saw one example of an XML document. However, I didn’t talk about any of the rules that you need to follow while creating it. It’s time now to discuss those rules of XML grammar. If you have worked with HTML, you will find that the rules of XML grammar are stricter than the HTML ones. However, this strictness is not a bad thing, because these rules help ensure that there are no errors while we parse, render, or exchange data.

Before I present the rules in detail, you need to familiarize yourself with the various parts of an XML document. Observe Figure 1-3 carefully.

```

Customers.xml  ✘
1  <?xml version="1.0" encoding="utf-8" ?>
2  <!-- This is list of customers -->
3  <customers>
4    <customer ID="C001">
5      <name>Nancy Davolio</name>
6      <email>nancy@localhost</email>
7      <comments>
8        <![CDATA[Regular customer since 1995]]>
9      </comments>
10     </customer>
11     <customer ID="C002">
12       <name>Steven Buchanan</name>
13       <email>steven@localhost</email>
14       <comments>
15         <![CDATA[New customer interested in multiple services]]>
16       </comments>
17     </customer>
18   </customers>

```

Figure 1-3. Parts of a typical XML document

Line 1 is called a processing instruction. A *processing instruction* is intended to supply some information to the application that is processing the XML document. Processing instructions are enclosed in a pair of <? and ?>. The `xml` processing instruction in Figure 1-3 has two attributes: `version` and `encoding`. The W3C recommendations for XML hold version 1.0, hence the `version` attribute is set to 1.0.

Note You may come across XML 1.1 while reading more about XML specifications. There are minor differences between XML 1.0 and XML 1.1. However, considering the wide acceptance for version 1.0 most of the XML documents prefer to mention that version. When you add a new XML file using Visual Studio it has its `version` attribute set to 1.0. You can find more details about these differences on the official web site of W3C.

Line 2 represents a comment. A *comment* can appear anywhere in an XML document after the `xml` processing instruction and can span multiple lines.

Line 3 contains the *document element* of the XML document. An XML document has one and only one document element. XML documents are like an inverted tree, and the document element is positioned at the root. Hence, the document element is also called a *root element*. Each element (whether or not it is the document element) consists of a start tag and an end tag. The start tag is `<customers>`, and the end tag is `</customers>`.

It is worthwhile to point out the difference between three terms: element, node, and tag. When you say *element*, you are essentially talking about the start tag and the end tag of that element together. When you say *tag*, you are talking about either the start tag or end tag of the element, depending on the context. When you say *node*, you are referring to an element and all its inner content, including child elements and text.

Inside the `<customers>` element, you have two `<customer>` nodes. The `<customer>` element has one attribute called `ID`. The attribute value is enclosed in double quotes. The `<customer>` element has three child elements: `<name>`, `<email>`, and `<comments>`. The text values inside elements, such as `<name>` and `<email>`, are often called *text nodes*. Sometimes, the text content that you want to put inside a node may contain special characters such as < and >. To represent such content, you use a character data (CDATA) section. Whatever you put inside the CDATA section is treated as a literal string. The `<comments>` tag shown in Figure 1-3 illustrates the use of a CDATA section.

Now that you have this background, you're ready to look at the basic rules of XML grammar. Any XML document that conforms to the rules mentioned next is called a *well-formed document*.

Markup Is Case Sensitive

Just like some programming languages, such as C#, XML markup is case sensitive. That means `<customer>`, `<Customer>`, and `<CUSTOMER>` all are treated as different tags.

A Document Must Have One and Only One Root Element

An XML document must have one and only one root element. In the preceding example, the `<customers>` element is the root element. Note that it is mandatory for XML documents to have a root element.

A Start Tag Must Have an End Tag

Every start tag must have a corresponding end tag. In HTML, this rule is not strictly followed—for example, tags such as `
` (line break), `<hr>` (horizontal rule), and `` (image) are often used with no end tag at all. In XML, that would not be well formed. The end tag for elements that do not contain any child elements or

text can be written by using shorter notation. For example, assuming that the `<customer>` tag doesn't contain any child elements, you could have written it as `<customer ID="C001"/>`.

Start and End Tags Must Be Properly Nested

In HTML, the rule about properly nesting tags is not followed strictly. For example, the following markup shows up in the browser correctly:

```
<B><I>Hello World</B></I>
```

This, however, is illegal in XML, where the nesting of start and end tags must be proper. The correct representation of the preceding markup in XML would be as follows:

```
<B><I>Hello World</I></B>
```

Attribute Values Must Be Enclosed in Quotes

In HTML, you may or may not enclose the attribute values. For example, the following is valid markup in HTML:

```
<IMG SRC=myphoto.jpg>
```

However, this is illegal in XML. All attribute values must be enclosed in quotes. Thus the accepted XML representation of the preceding markup would be as follows:

```
<IMG SRC="myphoto.jpg" />
```

DTD and XML Schema

Creating well-formed XML documents is one part of the story. The other part is whether these documents adhere to an agreed structure, or *Schema*. That is where Document Type Definition (DTD) and XML Schemas come into the picture.

DTDs and XML Schemas allow you to convey the structure of your XML document to others. For example, if I tell you to create an XML file, what structure will you follow? What is the guarantee that the structure that you create is the one that I have in mind? The problem is solved if I give you a DTD or an XML Schema for the document. Then, you have the exact idea as to how the document should look and what its elements, attributes, and nesting are.

The XML documents that conform to some DTD or XML Schema are called *valid documents*. Note that an XML document can be well formed, but it may not be valid if it doesn't have an associated DTD or Schema.

DTDs are an older way to validate XML documents. Nowadays, XML Schema—also called XML Schema Definition or XSD—is more commonly used to validate XML documents because of the advantages it offers. You will learn about the advantages of XSD over DTD in Chapter 5. Throughout our discussion, when I talk about validating XML documents, I will be referring to XML Schemas.

Parsing XML Documents

XML data by itself cannot do anything; you need to process that data to do something meaningful. As I have said, the software that processes XML documents is called a parser (or XML processor). XML parsers allow you read, write, and manipulate XML documents. XML parsers can be classified in three categories depending on how they process XML documents:

- DOM-based parsers (*DOM* stands for *Document Object Model*)
- SAX-based parsers (*SAX* stands for *Simple API for XML*)
- Pull-model parsers

DOM-based parsers are based on the W3C's DOM recommendations and are possibly the most common and popular. They look at your XML document as an inverted tree structure. Thus, our XML document shown in Figure 1-3 will be looked at by a DOM parser as shown in Figure 1-4.

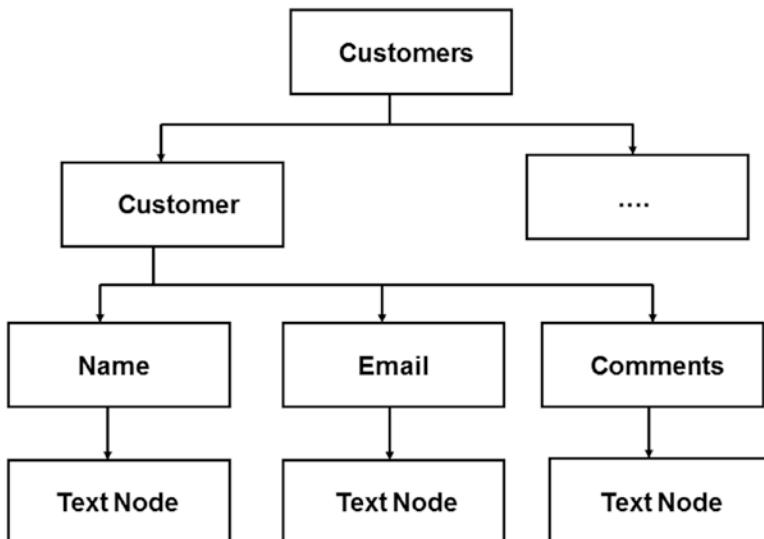


Figure 1-4. The DOM representation of an XML document

DOM-based parsers are read-write parsers, which means you can read as well as write to the XML document. They allow random access to any particular node of the XML document, and therefore, they need to load the entire XML document in memory. This also implies that the memory footprint of DOM-based parsers is large. DOM-based parsers are also called *tree-based parsers* for obvious reasons.

SAX-based parsers do not read the entire XML document into memory at once. They essentially scan the document serially from top to bottom. When they encounter various parts of the document, they raise events, and you can handle these events to read the document. SAX parsers are read-only parsers, which means you cannot use them to modify an XML document. They are useful when you want to read huge XML documents and loading such documents into memory is not advisable. These types of parsers are also called *event-based parsers*.

Pull-model parsers iterate through an XML document sequentially. They use the iterator design pattern to create an iterator. The iterator sequentially visits various parts of a document such as elements and attributes. You can inspect the type of the item under consideration to determine whether it's a start tag, end tag, or a text node. You can also read its attributes. Moreover, you can move the iterator to the next item. The .NET Framework's `XmlReader` falls in this category.

parsers can also be classified as validating and nonvalidating. *Validating parsers* can validate an XML document against a DTD or XML Schema as they parse the document. On the other hand, *nonvalidating parsers* lack this ability.

Note LINQ to XML offers an in-memory way of reading and writing XML documents. You will learn more about LINQ to XML later in this chapter. Chapter 13 covers the LINQ features as applicable to XML data manipulation in fuller details.

XSLT

XML solves the problem of data representation and exchange. However, often we need to convert this XML data into a format understood by the target application. For example, if your target is a web browser, the XML data must be converted to HTML before displaying in the browser.

Another example is that of business-to-business (B2B) applications. Let's say that application A captures order data from the end user and represents it in some XML format. This data then needs to be sent to application B that belongs to some other business. It is quite possible that the XML format as generated by application A is different from that required by application B. In such cases, you need to convert the source XML data to a format acceptable to the target system. In short, in real-world scenarios you need to transform XML data from one form to another.

That is where XSLT comes in handy. *XSLT* stands for *Extensible Style Sheet Language Transformations* and allows you to transform XML documents from one form into another. Figure 1-5 shows how this transformation happens.

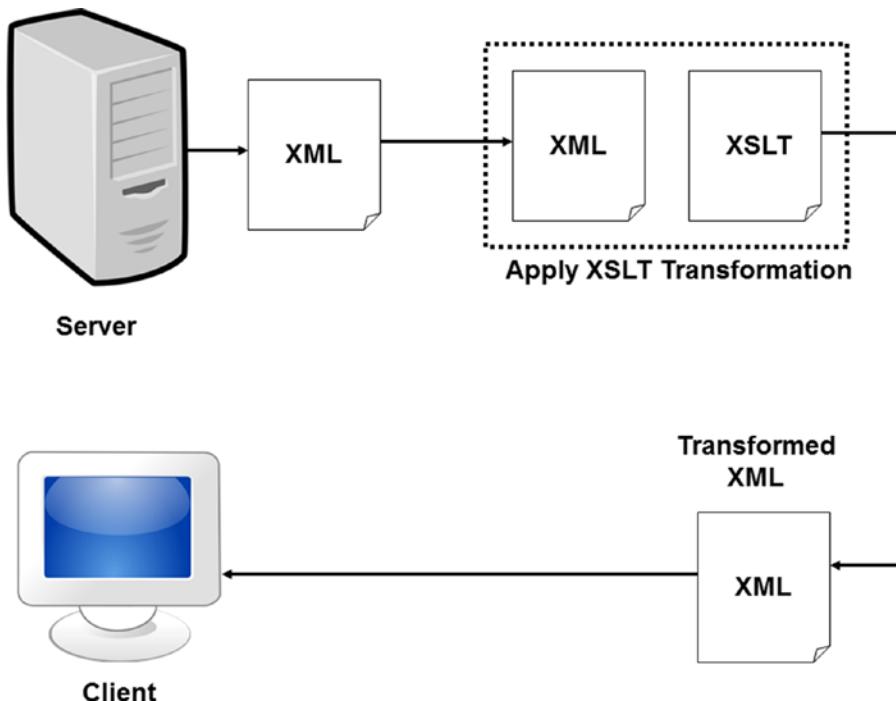


Figure 1-5. XML transformation using XSLT

XPath

Searching for and locating certain elements within an XML document is a fairly common task. *XPath* is an expression language that allows you to navigate through elements and attributes in an XML document. XPath consists of various XPath expressions and functions that you can use to look for and select elements and attributes matching certain patterns. XPath is also a W3C recommendation. Figure 1-6 shows an example of how XPath works.

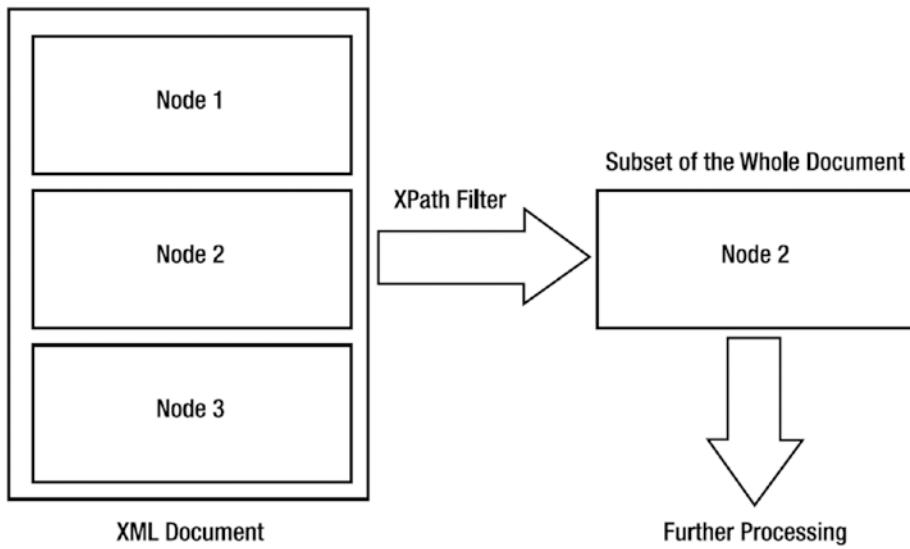


Figure 1-6. Using XPath to select nodes

The .NET Framework

Microsoft's *.NET Framework* is a platform for building Windows- and web-based applications, components, and services. Figure 1-7 shows the stack of the .NET Framework.

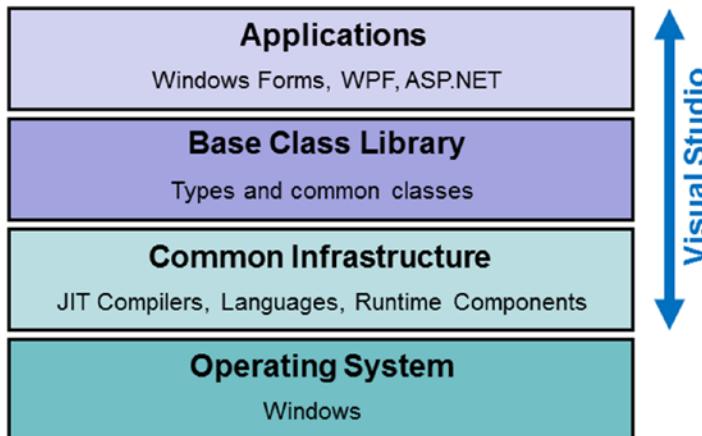


Figure 1-7. Stack of the .NET Framework

At the bottom level, you have the operating system. As far as the .NET Framework is concerned, your operating system will be one of the various flavors of Windows such as Windows 7, Windows 8.x, or Windows 10.

Note The .NET Framework should not be confused with .NET Core. They are different frameworks. The .NET Framework runs on the Windows platform, whereas .NET Core is a modular, cross-platform framework. We don't use .NET Core in this book. So, throughout the book when I say .NET, I mean the .NET Framework for Windows.

On top of the operating system, you have common infrastructure layer consisting of JIT compilers, languages, and other runtime components. This layer is the heart of the .NET Framework. It provides the executing environment and runtime services to all the .NET applications. Some of responsibilities of this layer include JIT compilation, memory management, thread management, and security checking.

Note This section discusses the basics of .NET Framework merely to brush up your understanding of the subject matter. Detailed coverage of the .NET Framework and its architecture is beyond the scope of this book.

On top of the Common Infrastructure layer, a huge collection of classes called the Base Class Library gets installed. The Base Class Library provides classes to perform almost everything that you need in your application. It includes classes for file input/output (IO), database access, XML manipulation, web programming, socket programming, and many more things. If you are developing a useful application in .NET, chances are that you will use one or another of the classes in the Base Class Library.

The top layer consists of various application models. Some of the choices are Windows Forms, Windows Presentation Foundation, and ASP.NET. In this book, you primarily develop Windows Forms based applications.

To develop these applications, you use Visual Studio. So, writing the code, compiling a project, debugging the code, and such tasks are accomplished from within the Visual Studio IDE.

.NET Framework and XML

The .NET Framework Base Class Library provides a rich set of classes that allows you to work with XML data. The relationship between the .NET Framework and XML doesn't end here. There are a host of other features that use XML. These features include the following:

- XML parsing
- XML transformation
- .NET configuration files
- ADO.NET
- ASP.NET Web Forms server controls
- XML serialization
- Web services, WCF services, and Web API
- XML documentation

- XAML markup
- SQL Server XML features

In this section, you will take a brief look at each of these features.

Assemblies and Namespaces

The XML-related classes from the Base Class Library are physically found in an assembly called `System.Xml.dll`. This assembly contains several namespaces that encapsulate various XML-related classes. The LINQ to XML classes are physically available in the `System.Xml.Linq.dll` assembly. In the following sections, you will take a brief look at some of the important namespaces from these assemblies.

System.Xml Namespace

The `System.Xml` namespace is one of the most important namespaces. It provides classes for reading and writing XML documents. Classes such as `XmlDocument` represent the .NET Framework's DOM-based parser, whereas classes such as `XmlTextReader` and `XmlTextWriter` allow you to quickly read and write XML documents. This namespace also contains classes that represent various parts of an XML document; these classes include `XmlNode`, `XElement`, `XmlAttribute`, and `XmlText`. We will be using many of these classes throughout this book.

System.Xml.Schema Namespace

The `System.Xml.Schema` namespace contains various classes that allow you to work with Schemas. The entire Schema Object Model (SOM) of .NET is defined by the classes from this namespace. These classes include `XmlSchema`, `XmlSchemaElement`, `XmlSchemaComplexType`, and many others.

System.Xml.XPath Namespace

The `System.Xml.XPath` namespace provides classes and enumerations for finding and selecting a subset of the XML document. These classes provide a cursor-oriented model for navigating through and editing the selection. The classes include `XPathDocument`, `XPathExpression`, `XPathNavigator`, `XPathNodeIterator`, and more.

System.Xml.Xsl Namespace

The `System.Xml.Xsl` namespace provides support for XSLT transformations. By using the classes from this namespace, you can transform XML data from one form to another. The classes provided by this namespace include `XslCompiledTransform`, `XslTransform`, `XsltSettings`, and so on.

System.Xml.Serialization Namespace

The `System.Xml.Serialization` namespace provides classes and attributes that are used to serialize and deserialize objects to and from XML format. These classes are extensively used in web services infrastructures. The main class provided by this namespace is `XmlSerializer`. Some commonly used attributes classes such as `XmlAttributeAttribute`, `XmlRootAttribute`, `XmlTextAttribute`, and many others are also provided by this namespace.

System.Xml.Linq Namespace

The `System.Xml.Linq` namespace contains classes related to the LINQ to XML features. Using these classes, you can manipulate XML documents and fragments efficiently and easily. Some of the important tasks that you can accomplish include loading XML from files or streams, creating XML trees via code, querying XML trees using LINQ operators, modifying XML trees, validating XML trees against Schemas, and transforming XML trees. Some of the frequently used classes from the `System.Xml.Linq` namespace are `XDocument`, `XElement`, `XNode`, `XAttribute`, and `XText`.

The Classic XML Parsing Model of the .NET Framework

The previous sections discussed three types of parsers: DOM- or tree-based parsers, SAX- or event-based parsers, and pull-model parsers. Out of these three models, the .NET Framework supports two.

In the .NET Framework, you can categorize the XML parsers into two flavors:

- Parser based on the DOM
- Parsers based on the pull-model or reader model

The first thing that may strike you is the lack of a SAX-based parser. But don't worry, the reader-based parsers provide similar functionality in a more efficient way.

The DOM-based parser of the .NET Framework is represented chiefly by a class called `XmlDocument`. By using this parser, you can load, read, and modify XML documents just as you would with any other DOM-based parser.

The reader-based parsers use a cursor-oriented approach to scan the XML document. The main class that is at the heart of these parsers is `XmlReader`. You also have `XmlWriter` at your disposal that allows you to write XML documents. These two classes are abstract classes, and other classes (such as `XmlTextReader` and `XmlTextWriter`) inherit from them. You can also create your own readers and writers if you so wish.

Thus to summarize, the .NET Framework supports DOM parsing and also provides a reader-model based parsers. I will be discussing these parsers thoroughly in subsequent chapters.

The LINQ-Based Parsing Model of the .NET Framework

Language Integrated Query, or LINQ, is a set of features that allows you to query in-memory collections, databases, and XML documents in a unified fashion. This implies that, irrespective of the underlying data source, your code will query the data in the same way. LINQ comes in three flavors:

- LINQ to objects
- LINQ to ADO.NET
- LINQ to XML

LINQ to objects provides a set of standard query operators for querying in-memory objects. The in-memory objects must implement the `IEnumerable<T>` interface. The most common objects for querying are generic `List` and `Dictionary` objects.

LINQ to ADO.NET provides a set of features for working with data from relational databases. LINQ to ADO.NET comes in three flavors: LINQ to `DataSet`, which allows you to query ADO.NET `DataSet` objects, and LINQ to SQL, which allows you to query relational databases such as SQL Server, and LINQ to Entities, which allows you to query Entity Framework entities.

LINQ to XML is a new approach to programming with XML data. It provides the in-memory document modification capabilities of the DOM in addition to supporting LINQ query operators. LINQ to XML operations are more lightweight than traditional DOM operations. Classes such as `XDocument`, `XElement`, `XNode`, `XAttribute`, and `XText` provide functionality equivalent to `XmlDocument` and its family of classes, as you'll see later in this book.

.NET Configuration Files

Almost all real-world applications require configuration, which includes things such as database connection strings, file system paths, security schemes, and other such settings. Prior to the introduction of the .NET Framework, developers often used .ini files or the Windows registry to store such configuration settings. But these approaches have their own flaws: no standardization, more coding time, more effort, and repeated coding for the same task.

Thankfully, the .NET Framework takes a streamlined and standardized approach to configuring applications. It relies on XML-based files for storing configuration information. That means .NET developers need not resort to .ini files or the Windows registry. Some of the advantages of using XML files instead of the classic approaches are as follows:

- Because XML files are more readable, the configuration data can be stored in a neat and structured way.
- To read the configuration information, the .NET Framework provides built-in classes. That means you need not write any custom code to access the configuration data.
- Storing the configuration information in XML files makes it possible to deploy it easily along with the application. In the past, Windows-registry-based configuration posed various deployment issues.
- There are no dangers in manipulating the XML configuration files for your application. In the past, developer's needed to tamper with the Windows registry that is risky and often created unwanted results.
- .NET Framework configuration files are not limited to using the predefined XML tags. You can extend the configuration files to add custom sections.
- Sometimes, the configuration information includes some confidential data. .NET Framework configuration files can be encrypted easily, giving more security to your configuration data. The encryption feature is a built-in part of the framework needing no custom coding from the developer.

The overall configuration files of the .NET Framework are of three types:

- Application configuration files
- Machine configuration files
- Security configuration files

Application configuration files store configuration information applicable to a single application. For Windows Forms and console-based applications, the name of the configuration file takes the following form:

```
<assembly name>.exe.config
```

That means that if you are developing a Windows application called `HelloWorld.exe`, its configuration filename must be `HelloWorld.exe.config`. The markup from Listing 1-2 shows sample configuration information for a Windows Forms-based application.

Listing 1-2. XML Markup from an Application Configuration File

```
<?xml version="1.0" encoding="utf-8" ?>
<configuration>
  <appSettings>
    <add key="defaultemail"
         value="someone@localhost"/>
  </appSettings>
</configuration>
```

On the other hand, a configuration file for an ASP.NET web application is called `web.config`. The markup in Listing 1-3 shows a sample `web.config` file.

Listing 1-3. XML Markup from a `web.config` File

```
<?xml version="1.0"?>
<configuration>
  <connectionStrings>
    <add name="connstr"
         connectionString="Data Source=.\SQLEXPRESS;
                           Integrated Security=True;
                           AttachDbFilename=|DataDirectory|AspNetDb.mdf"
         providerName="System.Data.SqlClient"/>
  </connectionStrings>
  <system.web>
    <compilation debug="true"/>
    <authentication mode="Forms">
      <forms name="login" loginUrl="login.aspx">
        </forms>
    </authentication>
    <authorization>
      <deny users="?"/>
    </authorization>
    <membership defaultProvider="AspNetSqlProvider">
      <providers>
        <add
             name="AspNetSqlProvider"
             type="System.Web.Security.SqlMembershipProvider"
             connectionStringName="connstr"
             passwordFormat="Clear"
             enablePasswordRetrieval="true"
             requiresQuestionAndAnswer="true"
             maxInvalidPasswordAttempts="3">
          </add>
        </providers>
      </membership>
    </system.web>
  </configuration>
```

When you install the .NET Framework on a machine, a file named `machine.config` gets created under the installation folder of the .NET Framework. This file is the master configuration file and contains configuration settings that are applied to all the .NET applications running on that machine. The settings

from `machine.config` can be overridden by using the application configuration file. Because the settings from `machine.config` are applied to all the .NET applications, it is recommended that you alter this file with caution. Generally, only server administrators and web-hosting providers modify this file.

The .NET Framework offers a secure environment for executing applications. It needs to check whether an assembly is trustworthy before any code in the assembly is invoked. To test the trustworthiness of an assembly, the framework checks the permission granted to it. This is called *Code Access Security*. Permissions granted to an assembly can be configured by using the security configuration files. These files are supposed to be changed using Code Access Security Policy tool (`Caspol.exe`). It is recommended that you alter these files only if you are aware of the impact they are going to have on security policy.

ADO.NET

For most business applications, data access is where the rubber meets the road. In .NET, *ADO.NET* is the technology for handling data access. Many new applications now use Entity Framework or similar frameworks to add OR/M (Object-Relational Mapping) capabilities to their applications. Entity Framework internally uses ADO.NET to get its job done.

ADO.NET gives a lot of emphasis to disconnected data access, though connected data access is also possible. A class called `DataSet` forms the cornerstone of the overall disconnected data architecture of ADO.NET. A `DataSet` class can be easily serialized as an XML document, and hence, it is ideal for data interchange, cross-system communication, and the like. The `SqlCommand` allows you to read data stored in Microsoft SQL Server and return it as an XML reader (`XmlReader`). XML-related features of ADO.NET are covered in detail in Chapter 7.

ASP.NET Web Forms Server Controls

You learned that the ASP.NET configuration file (`web.config`) is an XML file. The use of XML in ASP.NET doesn't end there. ASP.NET Web Forms use a special XML vocabulary to represent its server controls, which are programmable controls that can be accessed from server-side code. Consider the markup shown in bold in Listing 1-4.

Listing 1-4. Server Control Markup

```
<%@ Page Language="C#" %>
<script runat="server">
protected void Button1_Click(object sender, EventArgs e)
{
    Label2.Text = TextBox1.Text;
}
</script>

<html xmlns="http://www.w3.org/1999/xhtml" >
<body>
<form id="form1" runat="server">
<asp:Label ID="Label1" runat="server" Text="Enter some text :"></asp:Label>
<asp:TextBox ID="TextBox1" runat="server"></asp:TextBox>
<asp:Button ID="Button1" runat="server" Text="Submit" OnClick="Button1_Click" />
<asp:Label ID="Label2" runat="server"></asp:Label>
</form>
</body>
</html>
```

The preceding fragment shows the markup of a few ASP.NET Web Forms server controls. As you can see, a Label control is represented by the `<asp:Label>` markup tag. Similarly, a Button control is represented by the `<asp:Button>` markup tag. This is a special vocabulary of XML and follows all the rules of XML grammar.

XML Serialization

Modern applications seldom run on a single machine. They are distributed and span more than one machine. Figure 1-8 shows a simple distributed application spanning three machines.

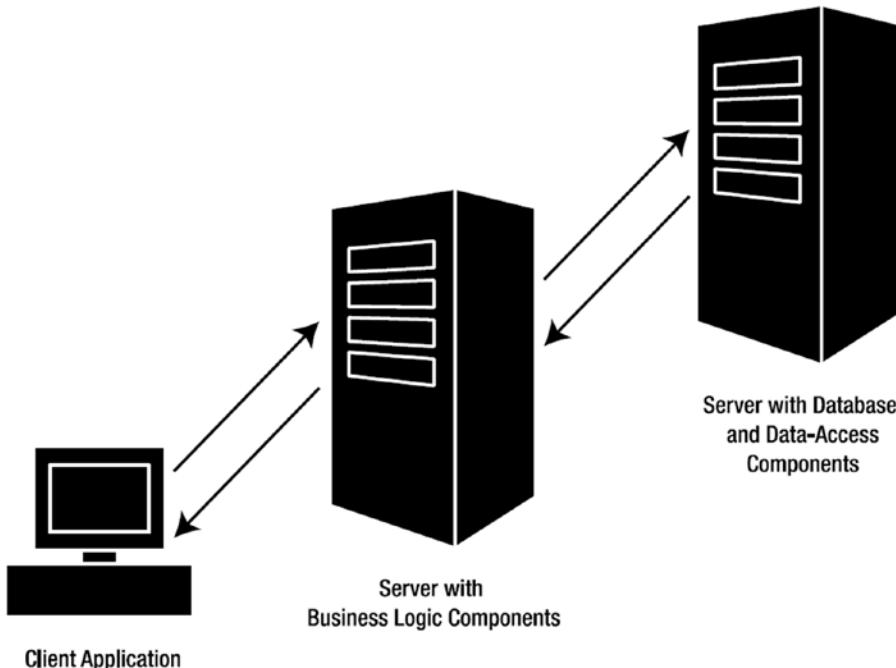


Figure 1-8. A simple distributed application

Here, the database and data-access components are located on a separate server. Similarly, business logic components are located on their own server, and the client applications access these components through a network. Imagine that the client wants some data from the database to display to the end user. The data is pulled out from the database from data-access components. But how will it reach the client? That is where serialization comes into the picture.

Serialization is a process by which data is written to some medium. In the preceding example, the medium is a network—but it can be a file or any other stream. The data-access components will serialize the requested data so that it can reach the client application. The client application then deserializes it—that is, it reads from the medium and reconstructs the data in an object or any other data structure. In the case of XML serialization, this data is serialized in the XML format. XML serialization is used extensively by web services, WCF services, and Web API.

The `XmlSerializer` and `DataContractSerializer` classes can be used to serialize and deserialize your objects.

Web Services, WCF Services, and Web API

With the evolution of the Internet, distributed applications are spanning different geographical locations. You may have one server residing in the United States with clients talking to it from India. It is quite possible that the clients and server are running two entirely different platforms (Windows and Unix, for example). In such cases, it is necessary that a standard mode of communication be established between the server and clients so that communication can take place over the Internet. That is where web services come into the picture.

Formally speaking, *web services* are a programmable set of APIs that you can call over a network by using industry-standard protocols: HTTP, XML, and an XML-based protocol called SOAP (as noted earlier in this chapter, *SOAP* stands for *Simple Object Access Protocol*). You can think of a web service as a web-callable component.

Because a web service is supposed to serve cross-platform environments, it relies heavily on XML. HTTP, XML, and SOAP form the pillars of web services architecture. Web services are industry standards, and just like XML, they are standardized by the W3C.

Have a look at Figure 1-8 again. Assume that the three machines involved are connected via the Internet and not a LAN. The components will now be replaced with web services, and they will perform the same jobs as the components did previously. In such cases, the client will call a web service residing on the business logic server, which in turn calls a web service residing on the database server. The requested data is sent back to the client in XML format (SOAP). It doesn't matter whether the client is a Windows desktop application, a Java application, or a web application. Powerful, isn't it? You will explore web services in later chapters.

Although web services are powerful, they have limitations of their own. Especially, the bulkiness of the data due to the verbose XML-based protocols make web services heavy. That's why new frameworks were developed to build services. Notably Windows Communication Foundation (WCF) and Web API are quite commonly used these days to build services. WCF is a generic framework for building services, whereas Web API is a framework for building RESTful (Representational State Transfer) services. Both of these frameworks—WCF and Web API—can deal with XML data. You will learn how in later chapters.

XML Documentation

Everybody knows the importance of well-documented code. However, this important task is often not given proper attention. One of the reasons is that comments left by the developer are not properly captured while creating program documentation or help files. C# as well as Visual Basic support a special commenting syntax that is based on XML. These XML comments can be converted into HTML documentation later. Just to give you a feel of how it works, see the C# code shown in Listing 1-5.

Listing 1-5. XML Commenting Syntax

```
/// <summary>
/// This is the starting point.
/// </summary>
/// <param name="args">
/// This parameter receives command line arguments.
/// </param>
static void Main(string[] args)
{
}
```

As you can see, the XML commenting syntax uses three slashes (///). The tags such as <summary> and <parameter> are built-in tags, and I will cover them in detail in subsequent chapters. To generate XML documentation out of this code, you need to view the project properties, as shown in Figure 1-9.

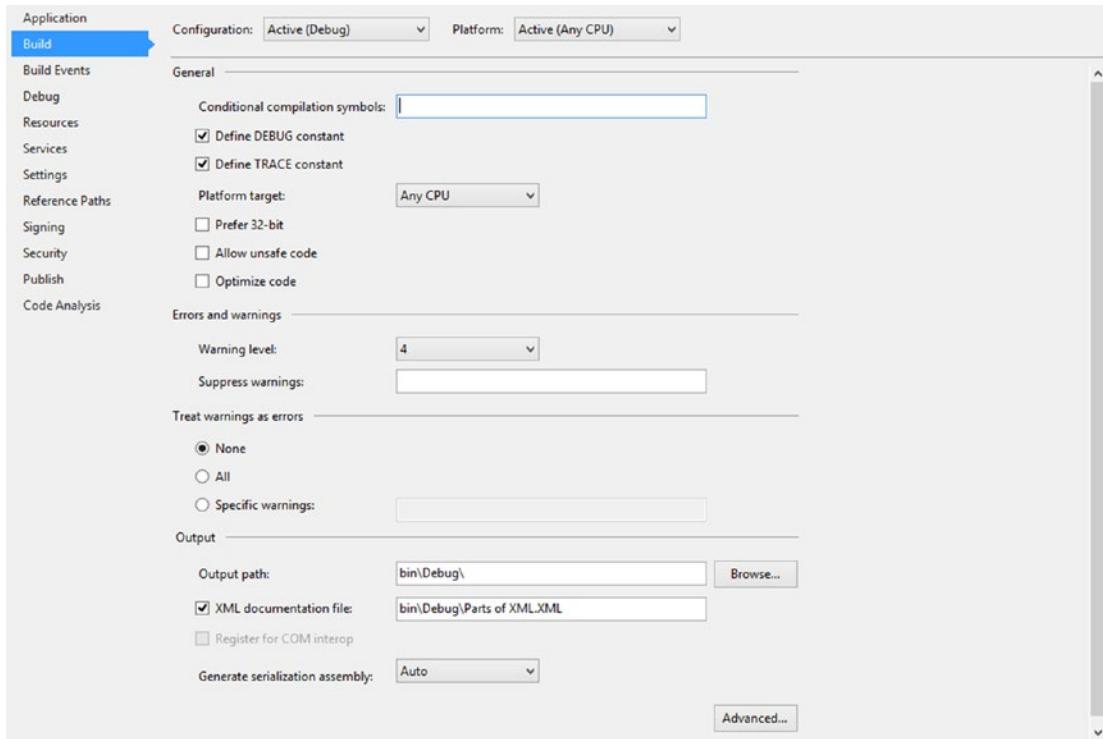


Figure 1-9. Configuring a project for XML documentation

Notice the check box titled XML Documentation File. After you select this check box and specify the output path, the compiler generates an XML file, as shown in Listing 1-6.

Listing 1-6. Resultant XML Comments

```
<?xml version="1.0"?>
<doc>
  <assembly>
    <name>Parts of XML</name>
  </assembly>
  <members>
    <member name="M:Parts_of_XML.Program.Main(System.String[])">
      <summary>
        This is the starting point.
      </summary>
    </member>
  </members>
</doc>
```

```

<param name="args">
    This parameter receives command line arguments.
</param>
</member>
</members>
</doc>

```

You can now apply an Extensible Style Sheet Language (XSL) style sheet to the preceding XML file to get HTML documentation out of it. You can also use third-party tools that utilize this XML to generate sophisticated help files.

XAML Markup

XAML (Extensible Application Markup Language) is a special vocabulary of XML used to define a user interface. For example, WPF applications use XAML to define their user interface. The XAML markup typically resides in files with the extension .xaml. The code responsible for the functioning of the application (runtime logic such as event handlers and methods) is housed in a C# class.

The XAML markup is an XML markup and hence follows all the rules of XML grammar. You can create/edit an XAML markup in any XML/text editor but Visual Studio provides a rich editor to work with it.

SQL Server XML Features

SQL Server is one of the most powerful database engines used today. Moreover, it is from the creators of the .NET Framework. Naturally, you can expect good XML support in the product.

SQL Server provides some extensions to the SELECT statement, such as FOR XML, AUTO, EXPLICIT, PATH, and RAW, that return the requested data in XML form. The XML data returned by these queries can be retrieved using the ExecuteXmlReader() method of the SqlCommand object. Further, Microsoft has released a set of managed classes called SQLXML that facilitate reading, processing, and updating data to and from SQL Server databases in XML format. Finally, SQL Server provides the `xml` data type to store XML data. I cover these features at length in Chapter 11.

Working with Visual Studio

Throughout the remainder of this book, you will be using Visual Studio 2017 for developing various applications. Hence, it is worthwhile to quickly illustrate how Visual Studio can be used to develop Windows and web applications. Note that this section is not intended to give you a detailed understanding of Visual Studio. Detailed coverage of these topics is beyond the scope of this book. I will restrict our discussion to the features that you need later in this book while building various examples.

Note Though the examples in this book are developed by using the professional edition of Visual Studio 2017, for most of the examples, you can also use Visual Studio 2017 Community Edition. You can download Visual Studio 2017 Community Edition from <https://www.visualstudio.com>.

Creating Windows Forms Applications

In this section, you will learn how to create a Windows Forms application using Visual Studio. To begin creating such an application, choose File ► New ► Project from the menu bar. This opens the New Project dialog box, shown in Figure 1-10.

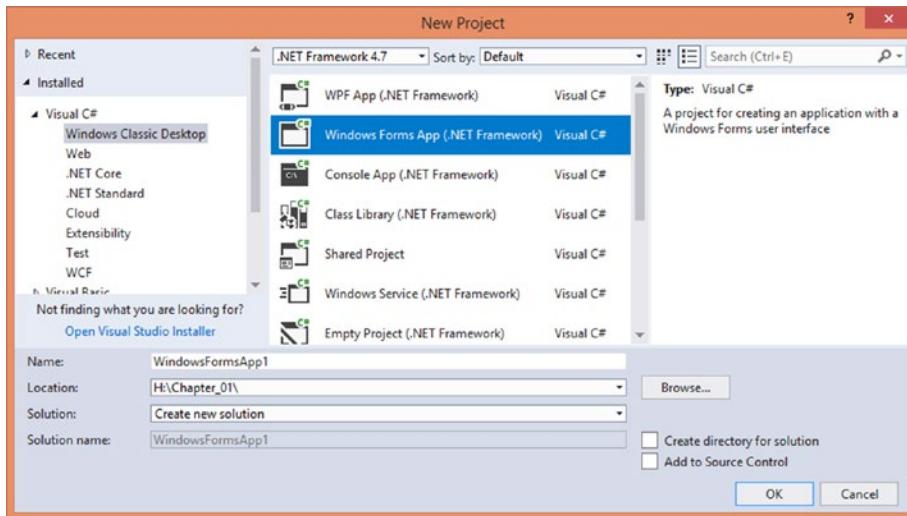


Figure 1-10. Creating a Windows Forms application in Visual Studio

Note The .NET Framework allows you to build Windows desktop applications using Windows Forms and Windows Presentation Foundation. In this book, we use Windows Forms to build most of the examples because it's quite easy to develop applications using Windows Forms. And it doesn't require knowledge of any additional technologies such as WPF and XAML (and also the associated Visual Studio designer). Using Windows Forms will allow us to stay focused on the main theme of this book, which is XML features of the .NET Framework.

Under Installed Templates, select Visual C#. This will display all the project templates applicable to the C#. Now, choose Windows Forms App from the templates. Type **HelloWindowsWorld** for the project name. Also, choose an appropriate location from your disk to store the project files. If you want, you can also specify a solution name for the Visual Studio solution file. Finally, click the OK button to create the project.

Your Visual Studio IDE should resemble Figure 1-11.

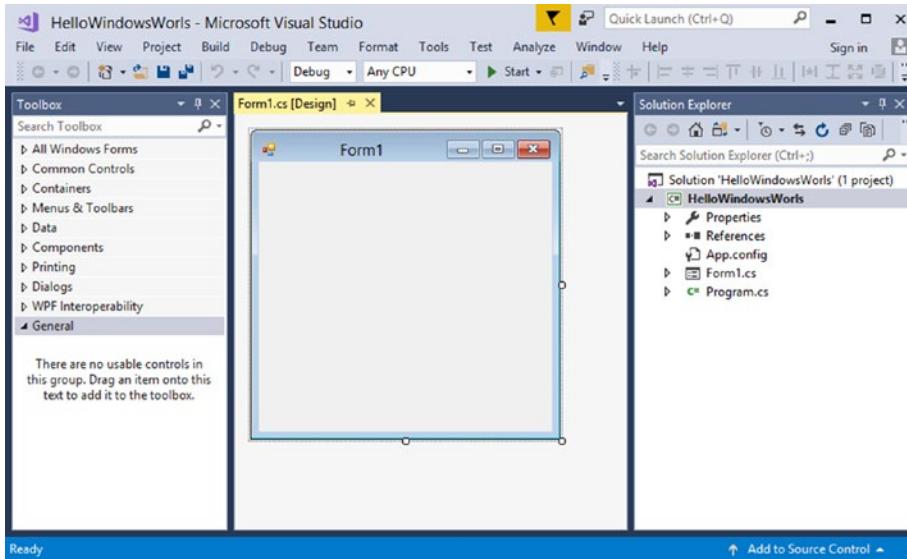


Figure 1-11. A newly created Windows application in the Visual Studio IDE

The project contains a single Windows Form. You can drag and drop controls from the toolbox onto the form and handle their events. Just to illustrate how this is done, drag and drop a Button control onto the form. Open the Properties window by using the View menu (or by pressing F4) and set its Text property to Click Me. Your form should now look similar to Figure 1-12.

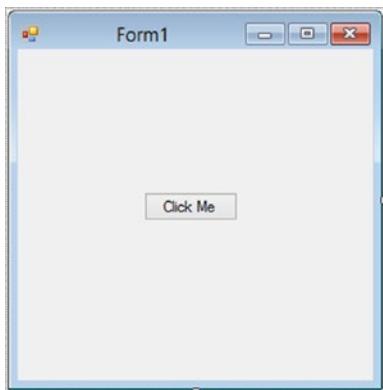


Figure 1-12. Windows form with a Button control

Double-click the Click Me button to go into its Click event handler. Type in the code shown in Listing 1-7.

Listing 1-7. Click Event Handler of the Button Control

```
private void button1_Click(object sender, EventArgs e)
{
    MessageBox.Show("Hello from Windows Forms");
}
```

The code shows the Click event handler of the Button control. Notice the signature of the event handler carefully. The first parameter of the event handler gives you the reference of the control (or object in general) that raised the event. The second parameter (often referred to as *event arguments*) supplies more information about the event, if any. The second parameter can be either an instance of the EventArgs class directly or of any other class inheriting from the EventArgs class.

Note You might be wondering why the *sender* parameter is needed. In the .NET Framework, one method can act as an event handler for multiple controls. For example, you can handle the Click event of two Button controls by writing just one event handler function. In such cases, the *sender* parameter can be used to identify the control that raised the event.

When you double-click a control, Visual Studio automatically takes you to its default event handler. However, you can wire various events and their handlers manually by using the Properties window. Figure 1-13 shows how this is done.

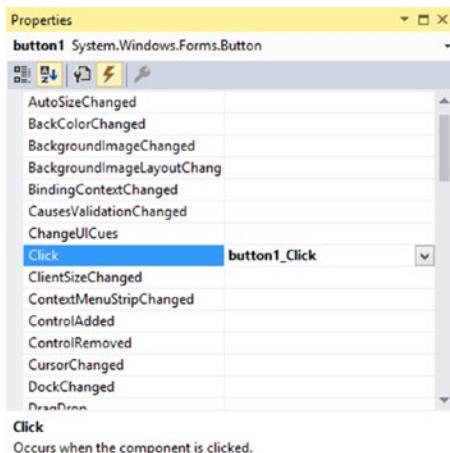


Figure 1-13. Wiring events and their handlers manually

Inside the event handler, we used the MessageBox class to display a message box. The Show() method of the MessageBox class has many overloads. We used the one that accepts a message to be displayed to the user.

Now, use the Build menu to compile the application. Compiling the application will create an executable .NET assembly. Though you can run the .exe directly, you may prefer to run the application via the Visual Studio IDE so that you can debug it if required. To run the application, choose Debug ► Start Debugging from the menu (or press F5). Figure 1-14 shows a sample run of the application.

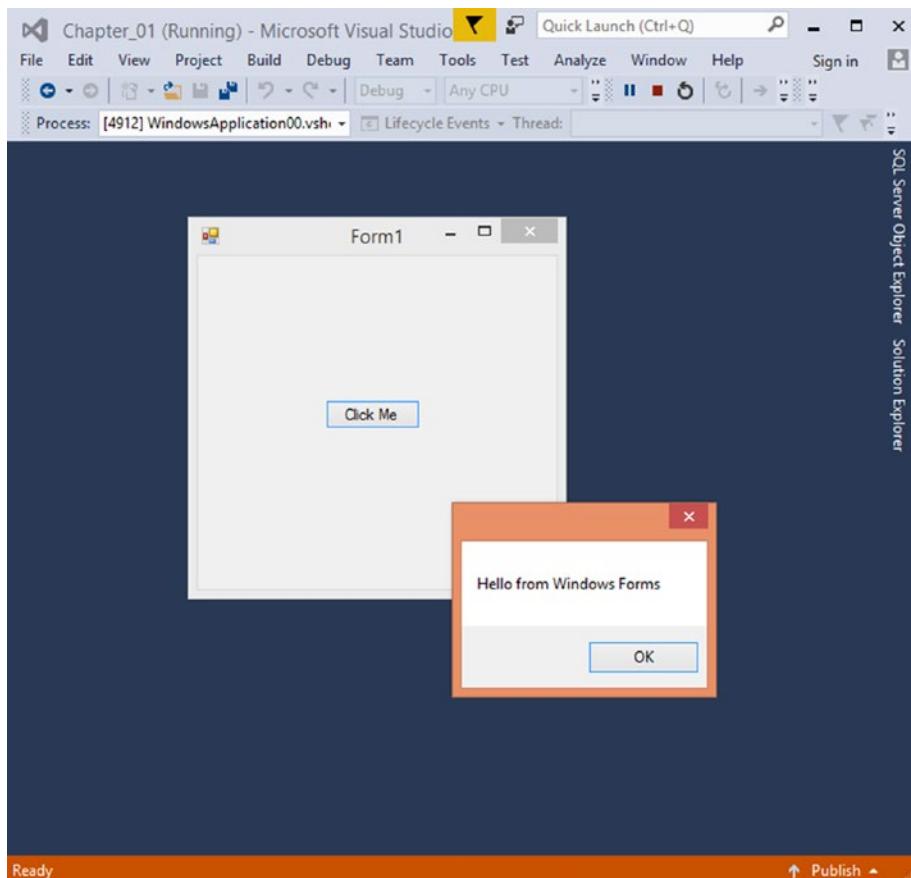


Figure 1-14. Sample run of the application

Creating Class Libraries

A project of type Windows Forms Application outputs an .exe assembly. Generally, such applications present some type of user interface to the user. However, at times, you need to code functionality and create a component. Such components reside as dynamic link libraries (.dll files) and generally do not include any presentation logic. To create dynamic link libraries by using Visual Studio, you need to create a project of type Class Library.

To learn how to create and consume class libraries, you will create a Class Library project. The resultant assembly will be consumed by the Windows Forms application that you developed in the preceding section.

Again, choose File ► New ► Project from the menu to open the New Project dialog, shown in Figure 1-15.

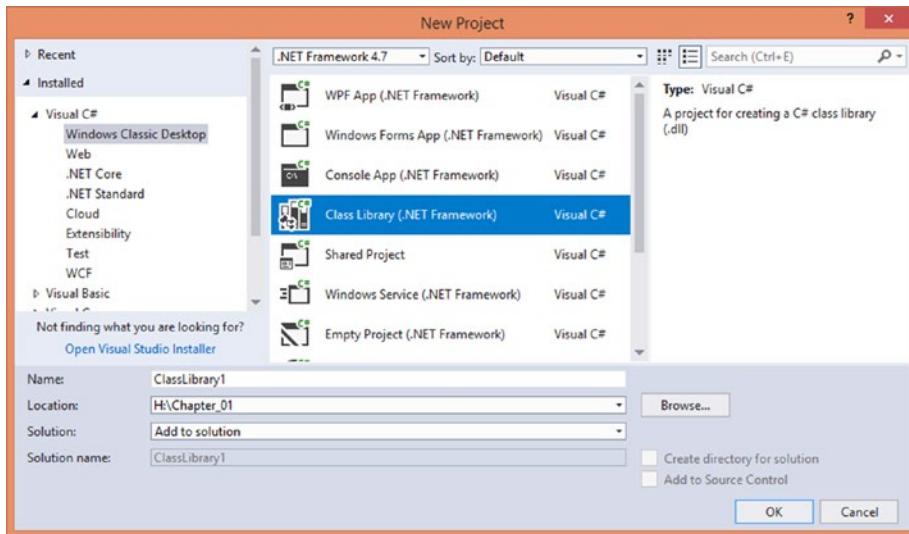


Figure 1-15. Adding a Class Library project

This time select the Class Library project template and type **HelloWorldLib** for the name. At the bottom of the dialog box, there is a combo box that allows you to add the new solution to the existing solution. Ensure that you choose Add to Solution in this combo box. Finally, click the OK button. Your Solution Explorer should now resemble Figure 1-16.

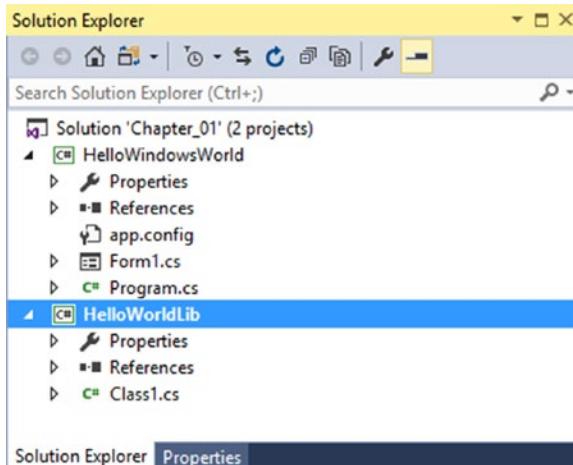


Figure 1-16. The Visual Studio IDE after adding the class library project

By default, the class library contains one class. You can, of course, add more classes at a later stage if required. Now, add a method named `HelloWorld()` in the class library. The method is shown in Listing 1-8.

Listing 1-8. `HelloWorld()` Method

```
public string HelloWorld()
{
    return "Hello from Windows Forms";
}
```

The method simply returns a string to the caller. Once we compile the class library as outlined before, our class library is ready to be consumed in another application.

Choose **Projects > Add Reference** (make sure you are in `HelloWindowsWorld` project) from the menu to open the Add Reference dialog box (see Figure 1-17).

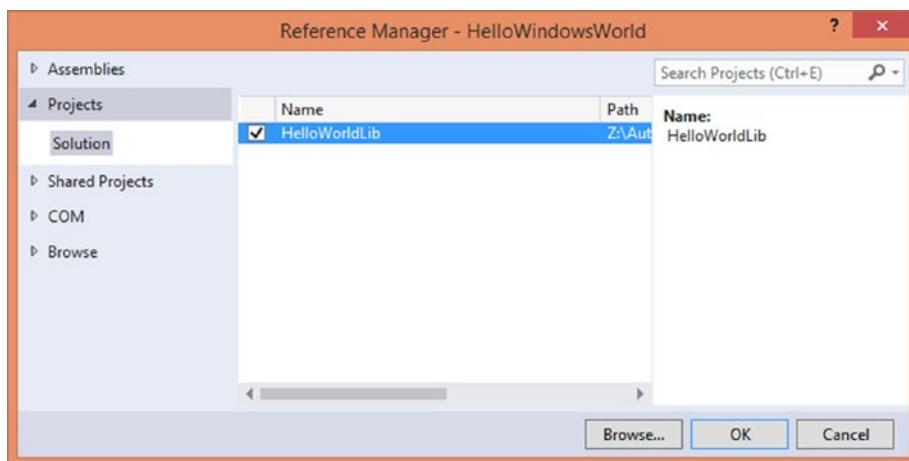


Figure 1-17. Adding a reference through the Add Reference dialog box

This dialog box contains several nodes on the left. The Assemblies and COM options are used to add a reference to built-in .NET Framework assemblies and COM components, respectively. The Projects option is used to add a reference to another project from the same solution. The Browse option can be used to add a reference to assemblies located somewhere on your machine. In our example, you need to add a reference to the `HelloWorldLib` assembly from the Projects option.

Now, change the code of the Windows Forms application as shown in Listing 1-9.

Listing 1-9. Modified Code of the Windows Forms Application

```
using System;
using System.Windows.Forms;
using HelloWorldLib;

namespace HelloWindowsWorld
{
    public partial class Form1 : Form
    {
```

```
public Form1()
{
    InitializeComponent();
}

private void button1_Click(object sender, EventArgs e)
{
    Class1 obj = new Class1();
    MessageBox.Show(obj.HelloWorld());
}
}
```

Notice the code marked in bold. The code imports the `HelloWorldLib` namespace with the help of a `using` statement. In the `Click` event handler, an object of `Class1` from the `HelloWorldLib` project is created. `HelloWorld()` is then called on the instance and supplied to the `Show()` method of the `MessageBox` class.

If you run the application after modifying the code as shown in Listing 1-9, you should get the same result as before.

Note You will learn more about web site and service types of projects in Chapters 9, 10, and 12.

Summary

XML is one of the most widely used standards for representing, exchanging, and transporting data across heterogeneous systems. All the members of the XML family of technologies (XML, XML Schema, XPath, and XSLT) are industry standards and hence enjoy massive support from all the software vendors. Developing cross-platform applications becomes easy with the help of such standards.

Microsoft has harnessed the full potential of XML while developing the .NET Framework. The `System.Xml` and `System.Xml.Linq` namespaces along with several sub-namespaces provide dozens of classes that allow you to read, write, and modify XML documents. The configuration files of .NET Framework applications exclusively use XML markup. Service development frameworks such as web services, WCF, and Web API also use XML. The C# language supports XML commenting, which you can use to generate XML documentation for your applications. The .NET Framework also allows you to leverage XML-related features of SQL Server easily.

CHAPTER 2



Manipulating XML Documents Using the Document Object Model

Chapter 1 discussed various flavors of parsers—tree-based parsers, event-based parsers, and pull-model parsers. You also learned that the Document Object Model (DOM) is a set of APIs for manipulating XML documents. To that end, this chapter covers all the essential functionality offered by the .NET Framework's DOM classes. Specifically this chapter covers the following topics:

- `System.Xml` classes related to DOM
- Knowing when to use DOM
- Reading XML documents using DOM
- Writing XML documents using DOM
- Dealing with whitespace and namespaces
- Handling events of the `XmlDocument` class

Using the DOM Parser

The `System.Xml` namespace provides a set of classes that together allow DOM manipulation of an XML document. At the heart of DOM manipulation in .NET Framework is a class called `XmlDocument`. This class is the DOM parser of the .NET Framework. Just like any other DOM parser, `XmlDocument` looks at your XML document as a tree. It loads the XML document and builds its tree representation (consisting of elements, attributes, comments, and so on) in memory.

For example, consider Listing 2-1.

Listing 2-1. Parts of a Typical XML Document

```
<?xml version="1.0"?>
<customers>
  <customer ID="C001">
    <name>Nancy Davolio</name>
    <email>nancy@localhost</email>
    <comments>
      <![CDATA[Regular customer since 1995]]>
    </comments>
  </customer>
```

```
<customer ID="C002">
  <name>Steven Buchanan</name>
  <email>steven@localhost</email>
  <comments>
    <![CDATA[New customer interested in multiple services]]>
  </comments>
</customer>
</customers>
```

The preceding XML document consists of the parts listed in Table 2-1.

Table 2-1. Parts of the XML Document

Part Name	Type of Part
<?xml ...?>	Processing instruction
customers	Document element or root node
customer	Element
ID	Attribute of the <customer> element
name	Child element of the <customer> element
email	Child element of the <customer> element
comments	Child element of the <customer> element

In addition to what is shown in the preceding table, the <name>, <email>, and <comments> elements contain text values that are called text nodes.

The preceding document is loaded in memory by the DOM parser as a tree and resembles Figure 2-1.

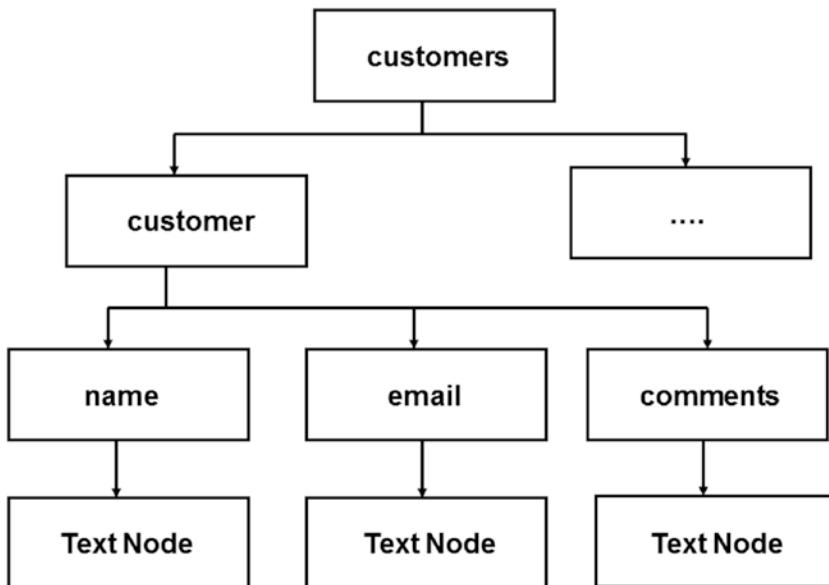


Figure 2-1. Tree representation of an XML document

Each part of the preceding diagram is actually a node. In .NET, a node is represented by an abstract class called `XmlNode`. Even text values and attributes are nodes. They are of course handled differently from the other nodes.

Each of the parts mentioned in Table 2-1 is represented by a class, each of which is described in Table 2-2.

Table 2-2. XML DOM Classes

Part of XML Document	Class Representing the Part
Document element	<code>XmlElement</code>
Processing instructions	<code>XmlProcessingInstruction</code>
Element	<code>XmlElement</code>
Attribute	<code>XmlAttribute</code>
Text values	<code>XmlText</code>
Nodes	<code>XmlNode</code>

All of the classes in Table 2-2 inherit directly or indirectly from an abstract base class `XmlNode`. While using the `XmlDocument` class, you will often use one or another of the classes from Table 2-2.

Knowing When to Use DOM

Before you go ahead and use DOM for accessing your XML documents, you should understand the areas to which DOM is best suited and areas where its use should be avoided.

The decision of whether to use DOM is governed by the following core factors:

- *Read/write access*: DOM allows you to read and write the XML document. But do you really need to change the underlying document?
- *Memory footprint*: DOM loads the entire document in memory. Naturally the memory footprint of DOM is larger. Are your documents large, say over 100MB?
- *Type of access*: DOM allows you to access any node randomly. This is possible because the entire document tree is available in memory. Do you need such access? Or is sequential access sufficient?

Answers to the preceding questions will help you to decide whether to use DOM. To summarize, DOM is best suited in the following scenarios:

- You want to modify the XML documents, that is, read-only access is not sufficient.
- You want to access various nodes randomly, that is, sequential access is not sufficient.
- You want to process documents that are small in size.
- The memory footprint is not a constraint.

A Sample XML Document

Throughout this chapter, we will be using an XML document that resides on the disk as a file named `Employees.xml`. The `Employees.xml` file is shown in Listing 2-2.

Listing 2-2. A Sample XML Document

```
<?xml version="1.0" encoding="utf-8" ?>
<!-- This is list of employees -->
<employees>
    <employee employeeid="1">
        <firstname>Nancy</firstname>
        <lastname>Davolio</lastname>
        <homephone>(206) 555-9857</homephone>
        <notes>
            <![CDATA[Education includes a BA in psychology from Colorado State University
            in 1970. She also completed "The Art of the Cold Call." Nancy is a member of
            Toastmasters International.]]>
        </notes>
    </employee>
    <employee employeeid="2">
        <firstname>Andrew</firstname>
        <lastname>Fuller</lastname>
        <homephone>(206) 555-9482</homephone>
        <notes>
            <![CDATA[Andrew received his BTS commercial in 1974 and a Ph.D. in international
            marketing from the University of Dallas in 1981. He is fluent in French and Italian
            and reads German. He joined the company as a sales representative, was promoted to
            sales manager in January 1992 and to vice president of sales in March 1993. Andrew
            is a member of the Sales Management Roundtable, the Seattle Chamber of Commerce, and
            the Pacific Rim Importers Association.]]>
        </notes>
    </employee>
    <employee employeeid="3">
        <firstname>Janet</firstname>
        <lastname>Leverling</lastname>
        <homephone>(206) 555-3412</homephone>
        <notes>
            <![CDATA[Janet has a BS degree in chemistry from Boston College (1984).
            She has also completed a certificate program in food retailing management. Janet was
            hired as a sales associate in 1991 and promoted to sales representative in February
            1992.]]>
        </notes>
    </employee>
</employees>
```

This XML document represents a list of employees. The `<employees>` element forms the document element and contains three `<employee>` child elements. The `<employee>` element has an attribute called `employeeid` and four sub-elements: `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>`. The `<notes>` element contains descriptive data that is stored as CDATA.

Note You might have guessed that the Employees.xml file is based on the Employees table of the Northwind database—a sample database for the SQL Server. Of course, we don't need the Northwind database for the examples of this chapter.

To create an XML file, you can enlist the help of the Visual Studio IDE, which enables you to quickly create XML documents by auto-completing end tags, putting attributes in quotes, and showing errors related to the document not being well formed. Because we will be using this file often, I recommend that you create it and keep it in a handy location on your hard disk.

Opening an Existing XML Document for Parsing

To open an existing XML document, you need to use the `XmlDocument` class. The `XmlDocument` class allows you to open XML documents in three common ways:

- You can specify the path to, or URL of, the XML file.
- You can use a stream object such as `FileStream` that contains the XML data.
- You can hold a string in memory that contains the XML data.

To see how each of the preceding approaches can be used, you need to develop a Windows Forms application like the one shown in Figure 2-2.

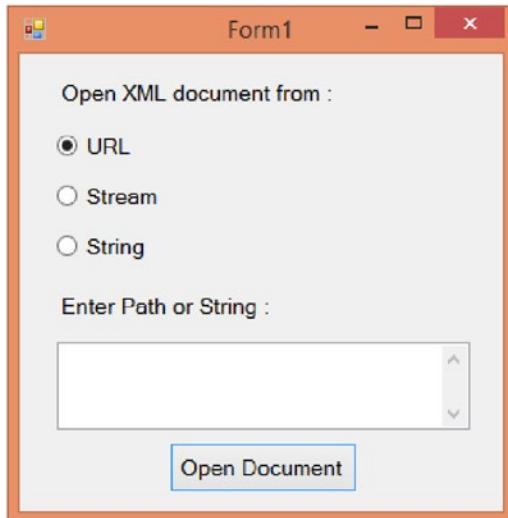


Figure 2-2. Opening an XML document

The application consists of three radio buttons for selecting the place from where the XML document is to be loaded. There is a text box for entering the file path, URL, or XML string. Finally, there is a button titled Open Document that opens the XML file depending on the selection and shows a message box with a success message.

Note I have not included any input validation or exception handling in the examples so as to keep the examples focused on the XML-related code. The code in this book's download contains the basic validation checks and exception handling wherever necessary.

Listing 2-3 shows the Click event handler of the button.

Listing 2-3. Opening an XML Document

```
private void button1_Click(object sender, EventArgs e)
{
    try
    {
        XmlDocument doc = new XmlDocument();
        if (radioButton1.Checked)
        {
            doc.Load(textBox1.Text);
        }
        if (radioButton2.Checked)
        {
            FileStream stream = new FileStream(textBox1.Text, FileMode.Open);
            doc.Load(stream);
            stream.Close();
        }
        if (radioButton3.Checked)
        {
            doc.LoadXml(textBox1.Text);
        }
        MessageBox.Show("XML Document Opened Successfully!");
    }
    catch(Exception ex)
    {
        MessageBox.Show(ex.Message);
    }
}
```

The code creates an instance of the `XmlDocument` class. The `XmlDocument` class has two important methods: `Load()` and `LoadXml()`. The former method can take a file system path, URL, or stream object pointing to the XML document that you want to open. The latter method accepts a string containing the XML data to be loaded. Depending on the selection made by the user, either `Load()` or `LoadXml()` is called. Note that depending on the selection, your text box should contain a URL, a file system path, or raw XML data.

Note You must import the `System.IO` and `System.Xml` namespaces to successfully compile the code shown in Listing 2-3. This applies to most of the examples illustrated in this chapter.

You can run the application and supply the path of the `Employees.xml` file that we created earlier.

Navigating Through an XML Document

An XML document consists of one or more nodes, and nodes can be nested inside other nodes. Such nested nodes are called *child nodes*.

The `XmlNode` class has a collection called `ChildNodes` that contains a list of child nodes of the node under consideration. Note that most of the other DOM-related classes are inherited directly or indirectly from the `XmlNode` class, and hence the `ChildNodes` collection is also available to them. Further, the `XmlNode` class has properties such as `ParentNode`, `FirstChild`, `LastChild`, `NextSibling`, and `PreviousSibling` that allow you to navigate to the corresponding node. Thus the `ParentNode` property will allow you to access the parent node of the current node, and the `NextSibling` property will allow you to access the next node at the same level as that of the current node.

To see how these properties can be used, we will develop a Windows Forms application. The application navigates through the `Employees.xml` file and displays a `TreeView` control with various nodes nested as per the document structure.

The application is shown in Figure 2-3.

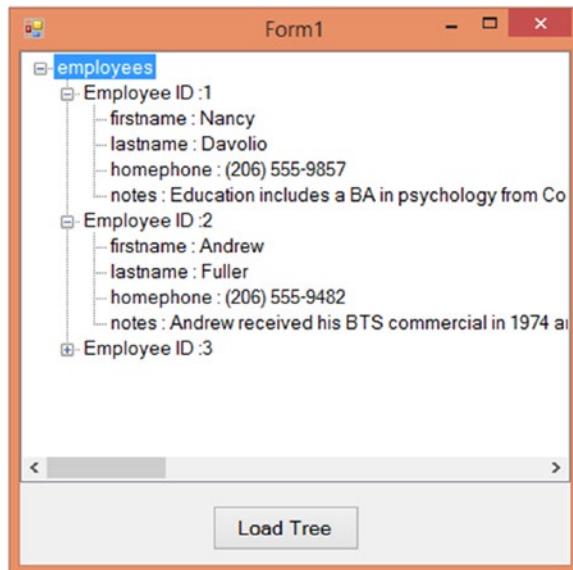


Figure 2-3. Navigating through an XML document by using DOM

The application consists of a `TreeView` control and a button titled `Load Tree`. After you click the button, the application loads the `Employees.xml` file by using the `XmlDocument` class. It then iterates through all the child nodes and reads the values of the attributes and nodes. The XML nodes are then added to the `TreeView` as `TreeNodes`.

Listing 2-4 shows the `Click` event handler of the `Load Tree` button.

Listing 2-4. Loading the Tree

```
private void button1_Click(object sender, EventArgs e)
{
    XmlDocument doc = new XmlDocument();
    doc.Load($"{Application.StartupPath}\\employees.xml");
```

```

TreeNode root = new TreeNode(doc.DocumentElement.Name);
treeView1.Nodes.Add(root);
foreach (XmlNode node in doc.DocumentElement.ChildNodes)
{
    TreeNode employee = new TreeNode("Employee ID :" +
        node.Attributes["employeedid"].Value);
    root.Nodes.Add(employee);
    if (node.HasChildNodes)
    {
        foreach (XmlNode childnode in node.ChildNodes)
        {
            TreeNode n2 = new TreeNode(childnode.Name + " : " + childnode.InnerText);
            employee.Nodes.Add(n2);
        }
    }
}
}

```

The code creates an instance of the `XmlDocument` class and loads the `Employees.xml` file using its `Load()` method. Then the code adds the root node of the `TreeView`. The XML document root node is `<employees>` and can be accessed by using the `DocumentElement` property of the `XmlDocument` class. The `DocumentElement` property is of type `XmlElement`. It has a property called `Name` that returns the name of the element (`employees`, in our case).

The `<employees>` node contains three `<employee>` child nodes, which can be accessed by using the `ChildNodes` property of the `DocumentElement`. A `foreach` loop then iterates through them. With each iteration, a new `TreeNode` is added to the `TreeView` with the employee ID as the text. To access the `employeedid` attribute, we use the `Attributes` collection of the `XmlNode` class. You can specify either an attribute's index or name to retrieve its value.

The code then checks whether the `<employee>` nodes have further child nodes. This is done using a Boolean property of the `XmlNode` class called `HasChildNodes`. If this property returns `true`, another `foreach` loop iterates through the child nodes of the `<employee>` node. With each iteration, a new `TreeNode` is added with text same as the name of the child node and its value. To retrieve the data inside nodes such as `<firstname>`, `<lastname>`, and so on, the code uses the `InnerText` property of the `XmlNode` class. The `InnerText` property returns concatenated values of the node and all its child nodes.

Looking for Specific Elements and Nodes

Often we are not interested in the entire XML document loaded in memory but a part of it. This requires us to search for a specific element or node for further processing. There are several methods used to search the XML document:

- Retrieving specific elements using the `GetElementsByTagName()` method
- Retrieving specific elements using the `GetElementById()` method
- Selecting specific nodes using the `SelectNodes()` method
- Selecting a single specific node using the `SelectSingleNode()` method

Retrieving Specific Elements Using the GetElementsByTagName() Method

The `GetElementsByTagName()` method of the `XmlDocument` class accepts the name of the tag (excluding `<` and `>`) and returns all the nodes matching that tag name. The matching nodes are returned as an `XmlNodeList`. The `XmlNodeList` class represents a collection of `XmlNode` objects.

To see `GetElementsByTagName()` in action, we need to develop a Windows Forms application like the one shown in Figure 2-4.

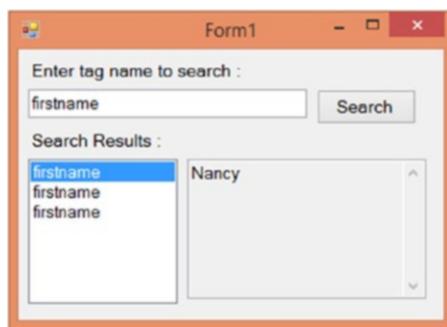


Figure 2-4. Using the `GetElementsByTagName()` method

The application consists of a text box to enter the tag name to look for. After you click the Search button, the matching tags are displayed in the list box. Selecting a tag from the list box displays its contents in a read-only text box.

The code that makes the preceding form work is shown in Listing 2-5.

Listing 2-5. Using the `GetElementsByTagName()` Method

```
XmlNodeList list = null;

private void button1_Click(object sender, EventArgs e)
{
    XmlDocument doc = new XmlDocument();
    doc.Load($"{Application.StartupPath}\\employees.xml");
    list = doc.GetElementsByTagName(textBox1.Text);
    listBox1.Items.Clear();
    foreach (XmlNode node in list)
    {
        listBox1.Items.Add(node.Name);
    }
}

private void listBox1_SelectedIndexChanged(object sender, EventArgs e)
{
    textBox2.Text = list[listBox1.SelectedIndex].InnerText;
}
```

The code declares a variable of type `XmlNodeList` at the form level. This variable needs to be declared at the form level because we need to access it in two event handlers.

In the Click event handler of the Search button, an `XmlDocument` instance is created. The `Employees.xml` file is loaded into it by using its `Load()` method. The code then calls the `GetElementsByTagName()` method of the `XmlDocument` object, which accepts the tag name to look for. In our application, the tag is specified in `textBox1`. As mentioned earlier, the return value of the `GetElementsByTagName()` method is of type `XmlNodeList`. The `XmlNodeList` class stores the collection of `XmlNode` objects. The code then iterates through the returned `XmlNodeList` and adds each node name into the list box.

The user can select any of the nodes displayed in the list box. In order to show the contents of the selected node, the code handles the `SelectedIndexChanged` event of the list box. Inside the `SelectedIndexChanged` event handler, the selected node is retrieved from the `XmlNodeList` we stored previously. The contents of the selected node are displayed using the `InnerXml` property of the `XmlNode` class, which returns all the XML content that is inside the node under consideration.

To see how the application works, run it from the Visual Studio IDE. Enter `firstname` in the search text box and click the Search button. The list box should display three `firstname` entries. This is expected because our XML document contains three `<employee>` nodes, each having a `<firstname>` child element of its own. Click any of the `firstname` entries from the list box. The text box beside the list box should show the value of the `firstname` node.

Retrieving Specific Elements Using the `GetElementById()` Method

Often, our XML elements have an attribute that is unique for each instance of that element in the XML document. We may want to look for a specific element based on this attribute value. This process is analogous to looking for a record in a database based on its primary key. The difference, however, is that the `XmlDocument` class does not know automatically that a specific attribute is acting as a primary key for that element. Formally, such an attribute is called the *ID* of that element.

To convey this information, you must use a DTD or Schema. Both of these techniques can mark an attribute as the ID of the element, and the `XmlDocument` class can then understand them as IDs. After you have a DTD or Schema attached to your XML document, you can call the `GetElementById()` method of the `XmlDocument` class. The `GetElementById()` method accepts the ID of the element to search for and returns that element as an instance of the `XmlElement` class. You can then access the sub-elements or text inside this element.

To illustrate the use of the `GetElementById()` method, we will build an application like the one shown in Figure 2-5.

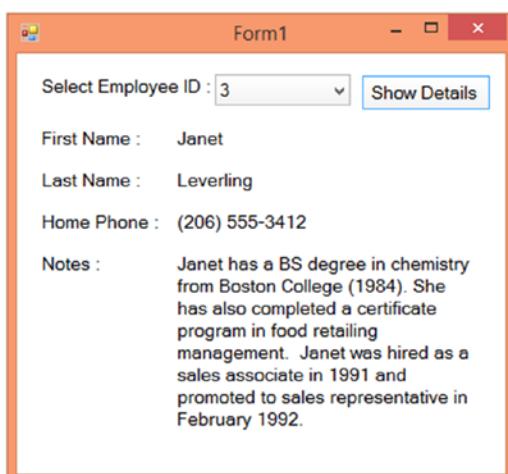


Figure 2-5. Using the `GetElementById()` method

The application consists of a combo box showing a list of employee IDs. After you select an ID and click the Show Details button, the details such as `firstname`, `lastname`, `homephone`, and `notes` are displayed.

Before you proceed with the application development, you must modify the `Employees.xml` file, as shown in Listing 2-6.

Listing 2-6. XML File with DTD

```
<?xml version="1.0" encoding="utf-8" standalone="yes" ?>
<!-- This is list of employees -->
<!DOCTYPE employees [
  <!ELEMENT employees ANY>
  <!ELEMENT employee ANY>
  <!ELEMENT firstname ANY>
  <!ELEMENT lastname ANY>
  <!ELEMENT homephone ANY>
  <!ELEMENT notes ANY>
  <!ATTLIST employee employeeid ID #REQUIRED>
]>

<employees>
  <employee employeeid="1">
    <firstname>Nancy</firstname>
    <lastname>Davolio</lastname>
    <homephone>(206) 555-9857</homephone>
    <notes>
      <![CDATA[Education includes a BA in psychology from Colorado State University
      in 1970. She also completed "The Art of the Cold Call." Nancy is a member of
      Toastmasters International.]]>
    </notes>
  </employee>
  <employee employeeid="2">
    <firstname>Andrew</firstname>
    <lastname>Fuller</lastname>
    <homephone>(206) 555-9482</homephone>
    <notes>
      <![CDATA[Andrew received his BTS commercial in 1974 and a Ph.D.
      in international marketing from the University of Dallas in 1981.
      He is fluent in French and Italian and reads German. He joined the company as a
      sales representative, was promoted to sales manager in January 1992 and to vice
      president of sales in March 1993. Andrew is a member of the Sales Management
      Roundtable, the Seattle Chamber of Commerce, and the Pacific Rim Importers
      Association.]]>
    </notes>
  </employee>
  <employee employeeid="3">
    <firstname>Janet</firstname>
    <lastname>Leverling</lastname>
    <homephone>(206) 555-3412</homephone>
  
```

```

<notes>
  <![CDATA[Janet has a BS degree in chemistry from Boston College (1984).
    She has also completed a certificate program in food retailing management. Janet was
    hired as a sales associate in 1991 and promoted to sales representative in February
    1992.]]>
</notes>
</employee>
</employees>

```

The document looks almost identical to the original. However, an important piece is added at the top (see the markup shown in bold). We have added a DTD for our document. I will not go into the details of the DTD here, but suffice it to say that the ATTLIST section defines an attribute called `employeeid` for the `<employee>` element. More important, the `employeeid` attribute is marked as the ID and is also a REQUIRED attribute. This is how the `XmlDocument` class knows which attribute of an element is acting as an ID.

If you look at the source code of the application, you will see a form-level variable of type `XmlDocument` called `doc`:

```
 XmlDocument doc = new XmlDocument();
```

The Load event handler of the form bears the code shown in Listing 2-7.

Listing 2-7. Populating the Combo Box

```

private void Form1_Load(object sender, EventArgs e)
{
  doc.Load($"{Application.StartupPath}\\employees.xml");
  foreach (XmlNode node in doc.DocumentElement.ChildNodes)
  {
    string employeeid = node.Attributes["employeeid"].Value;
    comboBox1.Items.Add(employeeid);
  }
}

```

The code loads the new `Employees.xml` file in the `XmlDocument` instance we created earlier by using its `Load()` method. A `foreach` loop then iterates over all the `<employee>` nodes. With each iteration, the `employeeid` attribute of the `<employee>` node is retrieved using the `Attributes` collection of the `XmlNode` class. The attribute value is added to the combo box.

When the user selects a particular ID, the details of that employee are displayed. This is accomplished in the `Click` event handler of the Show Details button. The code inside the `Click` event handler is shown in Listing 2-8.

Listing 2-8. Calling the `GetElementById()` Method

```

private void button1_Click(object sender, EventArgs e)
{
  XmlElement ele= doc.GetElementById(comboBox1.SelectedItem.ToString());
  label6.Text = elechildNodes[0].InnerText;
  label7.Text = ele.childNodes[1].InnerText;
  label8.Text = ele.childNodes[2].InnerText;
  label9.Text = ele.childNodes[3].InnerText;
}

```

The code calls the `GetElementById()` method of the `XmlDocument` class and passes the employee ID to look for. The `GetElementById()` method returns the matching element as an object of type `XmlElement`. Because the `XmlElement` class inherits from the `XmlNode` class, the `ChildNodes` collection is available to the `XmlElement` class also. To retrieve the values of the `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>` nodes, the `ChildNodes` collection is accessed by using the index of the corresponding element. Finally, the `InnerText` property of each `XmlNode` gives the text inside the appropriate node.

Selecting Specific Nodes Using the `SelectNodes()` Method

In complex cases, you may want to search for a node matching a pattern. This is accomplished with the help of XPath. Though XPath is not the subject of this chapter, I give you a glimpse of how it can be used. I explain XPath fully in Chapter 4.

The `XmlDocument` class has a method called `SelectNodes()` that accepts the XPath criteria for filtering the available nodes. It returns an `XXmlNodeList` containing the matching nodes.

To see how the `SelectNodes()` method works, we need to develop a Windows Forms application, as shown in Figure 2-6.

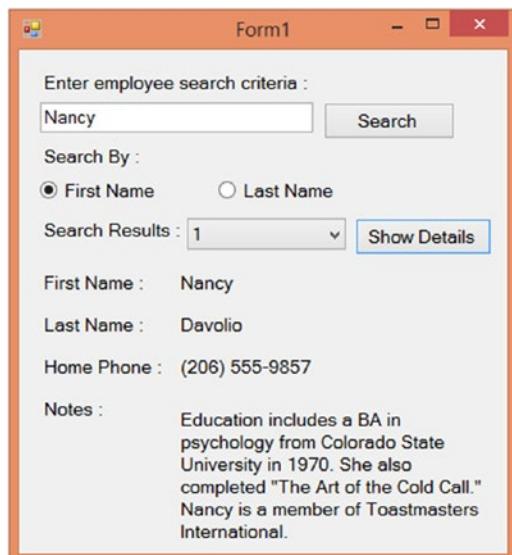


Figure 2-6. Using the `SelectNodes()` method

The application consists of a text box for entering the first name or last name of an employee. The radio buttons allow you to choose whether to look for matching first names or last names. Upon clicking the Search button, the `SelectNodes()` method is called. The returned `<employee>` nodes are collected in an `XXmlNodeList`. The combo box displays the list of matching employee IDs. You can select an employee ID and click the Show Details button to display the employee details.

If you look at the source code of the application, you will find a declaration of a variable of type `XXmlNodeList` at the form level:

```
XmlNodeList list = null;
```

We declare the variable at the form level because it is used in multiple event-handler functions.

The Click event handler of the Search button is shown in Listing 2-9.

Listing 2-9. Using the SelectNodes() Method

```
private void button1_Click(object sender, EventArgs e)
{
    XmlDocument doc = new XmlDocument();
    doc.Load("${Application.StartupPath}\employees.xml");
    if (radioButton1.Checked)
    {
        list = doc.SelectNodes("//employee[./firstname/text()='{" + textBox1.Text + "}')']");
    }
    else
    {
        list = doc.SelectNodes("//employee[./lastname/text()='{" + textBox1.Text + "}')']");
    }
    foreach (XmlNode node in list)
    {
        comboBox1.Items.Add(node.Attributes["employeeid"].Value);
    }
}
```

The preceding code first creates an instance of the `XmlDocument` class. It then loads the `Employees.xml` file by using the `Load()` method. Further, it checks the radio buttons to find out whether to search on the basis of first name or last name. We want to search `<employee>` nodes whose `<firstname>` or `<lastname>` matches the value entered in the text box. This is accomplished by calling the `SelectNodes()` method of the `XmlDocument` class. The `SelectNodes()` method takes the XPath string and returns an `XmlNodeList` containing the matching nodes. Look at the XPath syntax carefully. Because we want to select `<employee>` nodes, we specify `//employee`. But we are not interested in selecting all the `<employee>` nodes, so we place the filtering criterion in a pair of square brackets (`[]`). To represent the text value of the `<firstname>` and `<lastname>` nodes, we use the `text()` XPath function.

The code then iterates through the `XmlNodeList` and adds employee IDs to a combo box. The values of the `employeeid` attributes are retrieved by using the `Attributes` collection of the `XmlNode` class.

The user will select the employee ID whose details they want to see and will click the Show Details button. Listing 2-10 shows the code from the Click event handler of the Show Details button.

Listing 2-10. Displaying Employee Details

```
private void button2_Click(object sender, EventArgs e)
{
    label8.Text = list[comboBox1.SelectedIndex].ChildNodes[0].InnerText;
    label9.Text = list[comboBox1.SelectedIndex].ChildNodes[1].InnerText;
    label10.Text = list[comboBox1.SelectedIndex].ChildNodes[2].InnerText;
    label11.Text = list[comboBox1.SelectedIndex].ChildNodes[3].InnerText;
}
```

The code simply retrieves the desired `XmlNode` from the `XmlNodeList`. The child nodes of the node are accessed by using the `ChildNodes` collection. The `InnerText` property of the `XmlNode` class returns the text from each child node.

Selecting a Single Specific Node Using the SelectSingleNode() Method

The `SelectSingleNode()` is very similar to the `SelectNodes()` method that you just learned, with one difference. Instead of returning a list of `XXmlNode` objects in the form of an `XXmlNodeList`, it simply returns the first matching `XXmlNode`.

To test this method, you can modify the previous example, as shown in Listing 2-11.

Listing 2-11. Using the `SelectSingleNode()` Method

```
XmlNode node = null;

private void button1_Click(object sender, EventArgs e)
{
    XmlDocument doc = new XmlDocument();
    doc.Load($"{Application.StartupPath}\\employees.xml");
    if (radioButton1.Checked)
    {
        node = doc.SelectSingleNode($"//employee[./firstname/text()='{textBox1.Text}']");
    }
    else
    {
        node = doc.SelectSingleNode($"//employee[./lastname/text()='{textBox1.Text}']");
    }
    if (node != null)
    {
        comboBox1.Items.Add(node.Attributes["employeeid"].Value);
    }
}

private void button2_Click(object sender, EventArgs e)
{
    label8.Text = node.ChildNodes[0].InnerText;
    label9.Text = node.ChildNodes[1].InnerText;
    label10.Text = node.ChildNodes[2].InnerText;
    label11.Text = node.ChildNodes[3].InnerText;
}
```

The code now declares a variable of type `XXmlNode` at the form level. The `Click` event handler of the Search button calls the `SelectSingleNode()` method, which accepts the same XPath expression as in the previous example. This method returns the first matching node instead of an `XXmlNodeList`, though our search criteria may not necessarily return any matching node. Therefore, the code accesses the `XXmlNode` variable only if it is not null. In the `Click` event of the Show Details button, the `XXmlNode` variable `node` is used to retrieve employee details.

Modifying XML Documents

Up until this point, we have seen how to read XML documents; how to navigate through them; and how to search them on the basis of tag names, IDs, and XPath expressions. But what about modifying them? That's the topic of this section.

Often business requirements call for modification of the underlying XML document. This modification can be an addition, a deletion, or a change of nodes or attributes. As you saw previously, DOM is a read-write parser. That means DOM APIs also allow you to modify the document.

To illustrate the use of several `System.Xml` classes for modifying XML documents, we are going to develop a Windows Forms application like the one shown in Figure 2-7.

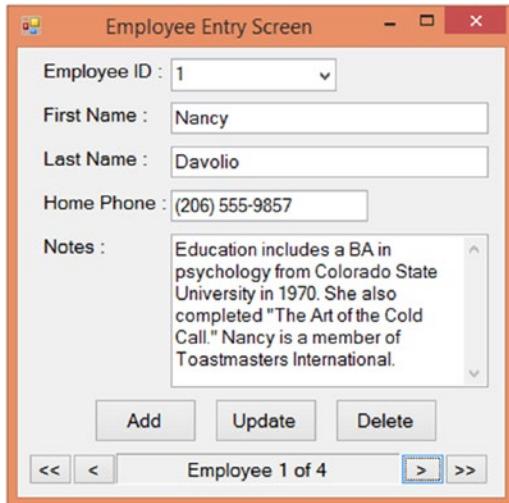


Figure 2-7. Data entry screen for the `Employees.xml` file

The application represents a complete data entry screen for the `Employees.xml` file. The application allows us to do the following tasks:

- Navigate among the available employees with the help of VCR buttons (the buttons used to navigate to the previous, next, first, and last records are often called *VCR buttons*).
- Add a new employee.
- Modify the details of a particular employee. The employee ID attribute acts like a primary key for our XML document, and hence it cannot be changed.
- Delete an existing employee.

If you look at the source code of the preceding application, you will see two form-level variables, as shown here:

```
 XmlDocument doc = new XmlDocument();
int CurrentNodeIndex = 0;
```

The `XmlDocument` instance is used throughout the application. The integer variable `CurrentNodeIndex` is used to keep track of the current employee record that is being displayed (it is mainly used by the navigational buttons).

The Load event handler of the form is shown in Listing 2-12.

Listing 2-12. Filling Controls

```
private void Form1_Load(object sender, EventArgs e)
{
    doc.Load($"{Application.StartupPath}\\\employees.xml");
    foreach (XmlNode node in doc.DocumentElement.ChildNodes)
    {
        comboBox1.Items.Add(node.Attributes["employeeid"].Value);
    }
    FillControls();
}
```

The preceding code loads the `Employees.xml` file by using the `Load()` method. It then iterates through all the `<employee>` nodes and fills the combo box with employee IDs. The `employeeid` attribute is retrieved by using the `Attributes` collection of the `XmlNode` class. Finally, the code calls a helper method called `FillControls()`. This method simply displays first name, last name, home phone, and notes from the current `<employee>` node in various text boxes. We will be looking at the `FillControls()` method shortly.

Navigating Between Various Nodes

The application allows you to navigate between various `<employee>` nodes with the help of VCR navigation buttons. Listing 2-13 shows how the navigation buttons work.

Listing 2-13. Working of Navigation Buttons

```
//go to first record
private void button4_Click(object sender, EventArgs e)
{
    CurrentNodeIndex = 0;
    FillControls();
}

//go to previous record
private void button5_Click(object sender, EventArgs e)
{
    CurrentNodeIndex--;
    if (CurrentNodeIndex < 0)
    {
        CurrentNodeIndex = 0;
    }
    FillControls();
}

//go to next record
private void button6_Click(object sender, EventArgs e)
{
```

```

    CurrentNodeIndex++;
    if (CurrentNodeIndex >= doc.DocumentElement.ChildNodes.Count)
    {
        CurrentNodeIndex = doc.DocumentElement.ChildNodes.Count - 1;
    }
    FillControls();
}

//go to last record
private void button7_Click(object sender, EventArgs e)
{
    CurrentNodeIndex = doc.DocumentElement.ChildNodes.Count - 1;
    FillControls();
}

```

In the Click event of the First Record (<<) button, the code sets the CurrentNodeIndex variable to 0 and calls the FillControls() method. The FillControls() method then populates various controls based on the value of the CurrentNodeIndex variable.

The Click event handler of the Previous Record (<) button decrements the CurrentNodeIndex variable. If the value becomes less than zero, the event handler sets it to 0. The FillControls() method is then called.

In the Click event handler of the Next Record (>) button, the code increments the CurrentNodeIndex variable. If the value goes beyond the total number of <employee> nodes, the event handler sets a new value of the total number of employee nodes minus one. This is necessary because just like any other collection in .NET, the ChildNodes collection is zero based.

Finally, the Click event handler of the Last Record (>>) button sets the CurrentNodeIndex variable to the total number of employee nodes minus one.

Now that you know how the navigation system of the application works, let's move on to the more interesting part—modifying, deleting, and adding XML content.

Modifying Existing Content

To modify an <employee> node, we first need to retrieve it from the list of <employee> nodes. The ID of the employee will be taken from the combo box. To retrieve the <employee> node, we can use the SelectNodes() or SelectSingleNode() method. In our example, because there can be only one <employee> node matching the given employee ID, SelectSingleNode() is a better choice. After a reference to the <employee> node is retrieved, we can change its child nodes. The complete code implementing this logic is shown in Listing 2-14.

Listing 2-14. Modifying Existing Content

```

private void button2_Click(object sender, EventArgs e)
{
    XmlNode node=doc.SelectSingleNode("//employee[@employeeid='{comboBox1.Text}']");
    if (node != null)
    {
        nodechildNodes[0].InnerText = textBox1.Text;
        node.childNodes[1].InnerText = textBox2.Text;
        node.childNodes[2].InnerText = textBox3.Text;
        XmlCDataSection notes = doc.CreateCDataSection(textBox4.Text);
        node.childNodes[3].ReplaceChild(notes, node.childNodes[3].childNodes[0]);
    }
}

```

```
doc.Save($"{Application.StartupPath}\\employees.xml");
}
```

First, the code retrieves the `<employee>` node matching the selected employee ID by using the `SelectSingleNode()` method. Carefully note the XPath expression that is used. In XPath expressions, attributes are prefixed with the `@` symbol. Thus `@employeeid` refers to the `employeeid` attribute of the `<employee>` node. The `SelectSingleNode()` method returns the selected node in the form of an `XmlNode` object. Before we proceed and change its contents, we need to ensure that the `SelectSingleNode()` has returned a node. This is done by checking whether the node returned is null or otherwise.

The `XmlNode` returned from the `SelectSingleNode()` method will be an `<employee>` node. That means it will have four child nodes: `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>`. The `InnerText` property of these four child nodes is nothing but the text values of the corresponding node. Inside the `if` condition, the code sets the `InnerText` property of all four child nodes to the values from respective text boxes. There is one interesting thing to note here. The `<notes>` element contains free text that can feature special markup symbols such as `<`, `>`, and `".`. If we simply assign the `InnerText` property of the `<notes>` node to the new value, it can create problems when accessing the document later.

Remember that we wrote the contents of the `<notes>` node as a CDATA section to avoid just such a problem, so we must write the new data as a CDATA section as well. The CDATA section is represented by a class called `XmlCDataSection`. The `CreateCDataSection()` method of the `XmlDocument` class creates a new CDATA section with the supplied text (the entire text supplied is placed within `<![CDATA[. . .]]>`). To change the content of an existing CDATA section, the code calls the `ReplaceChild()` method of the `XmlNode` class. The `ReplaceChild()` method accepts the new node and the old node as parameters. The old node is then replaced with the new node.

After you make any changes to an XML document, the entire document must be saved to disk in order to persist the changes. This is accomplished using the `Save()` method of the `XmlDocument` class. The `Save()` method accepts the target path where you would like to save the file. In our example, because we want to overwrite the existing `Employees.xml` file with the modified version, we supply the same path as that of the original file.

Deleting Existing Content

Deleting an `<employee>` node requires finding it from the list of available employees based on the employee ID and then removing it from the document. The code that implements the delete feature is shown in Listing 2-15.

Listing 2-15. Deleting a Node

```
private void button3_Click(object sender, EventArgs e)
{
    XmlNode node = doc.SelectSingleNode("//employee[@employeeid='{comboBox1.Text}']");
    if (node != null)
    {
        doc.DocumentElement.RemoveChild(node);
    }
    doc.Save($"{Application.StartupPath}\\employees.xml");
    UpdateLabel();
}
```

The code retrieves the node that we want to delete by using the `SelectSingleNode()` method. To delete a node from the `ChildNodes` collection, the `XmlNode` class provides a method called `RemoveChild()`. The `RemoveChild()` method accepts a reference to the `XmlNode` that is to be removed from the `ChildNodes` collection. In our case, we want to remove the entire `<employee>` node, which is a child node of the `<employees>` root element. Hence the code calls the `RemoveChild()` method on the `DocumentElement`, that is, the root node of the document.

After the node is deleted, the file is saved to disk by using the `Save()` method of the `XmlDocument` class. The `UpdateLabel()` helper method simply updates the current record number displayed on the status label.

Adding New Content

The code that adds a new employee is a bit lengthier than our previous examples. It is more interesting too. You will now learn how to create XML document contents from the ground up. Creating elements, attributes, text nodes, and CDATA sections will all be demystified in this section.

First of all, let's count the elements, attributes, and nodes that we need to create in order to add a new employee to our XML document. Here is a list of nodes that we need to add:

- An `<employee>` element
- A `<firstname>` element
- A `<lastname>` element
- A `<homephone>` element
- A `<notes>` element
- An `employeeid` attribute for the `<employee>` element
- A text node for the `<firstname>` value
- A text node for the `<lastname>` value
- A text node for the `<homephone>` value
- A CDATA section for the `<notes>` value

Note one important thing: the text that appears as the value of the `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>` elements is also treated as a node.

The complete code that implements an employee addition is shown in Listing 2-16.

Listing 2-16. Adding a New Node

```
private void button1_Click(object sender, EventArgs e)
{
    XmlElement employee = doc.CreateElement("employee");
    XmlElement firstname = doc.CreateElement("firstname");
    XmlElement lastname = doc.CreateElement("lastname");
    XmlElement homephone = doc.CreateElement("homephone");
    XmlElement notes = doc.CreateElement("notes");

    XmlAttribute employeeid = doc.CreateAttribute("employeeid");
    employeeid.Value = comboBox1.Text;
```

```

XmlText firstnametext = doc.CreateTextNode(textBox1.Text);
XmlText lastnametext = doc.CreateTextNode(textBox2.Text);
XmlText homephonetext = doc.CreateTextNode(textBox3.Text);
XmlCDataSection notestext = doc.CreateCDataSection(textBox4.Text);

employee.Attributes.Append(employeeid);
employee.AppendChild(firstname);
employee.AppendChild(lastname);
employee.AppendChild(homephone);
employee.AppendChild(notes);

firstname.AppendChild(firstnametext);
lastname.AppendChild(lastnametext);
homephone.AppendChild(homephonetext);
notes.AppendChild(notestext);

doc.DocumentElement.AppendChild(employee);
doc.Save($"{Application.StartupPath}\\employees.xml");

UpdateLabel();
}

```

The code creates five elements by using the `CreateElement()` method of the `XmlNode` class. These five elements are `<employee>`, `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>`. The `CreateElement()` method accepts the tag name of the element and returns an object of type `XmlElement`. Note that `XmlElement` inherits from the `XmlNode` class.

An attribute is represented by the `XmlAttribute` class and is created using the `CreateAttribute()` method of the `XmlNode` class. The `CreateAttribute()` method accepts the attribute name as a parameter, in this case `employeeid`. The value of the attribute can be assigned by setting the `Value` property of the `XmlAttribute` class.

The code proceeds to create three text nodes that represent the values of the `<firstname>`, `<lastname>`, and `<homephone>` elements, respectively. Text nodes are represented by a class called `XmlText`. To create these text nodes, the code uses the `CreateTextNode()` method of the `XmlNode` class. The `CreateTextNode()` method accepts the value of the text node as a parameter.

As I said earlier, the `<notes>` element contains character data (CDATA), and a CDATA section is represented by a class called `XmlCDataSection`. As we did before, we create the CDATA section by using the `CreateCDataSection()` method of the `XmlNode` class.

This completes the element, attribute, and node creation. The code then proceeds to nest various elements as per the required XML structure.

All the attributes of an `XmlNode` are stored in its `Attributes` collection. To add the `employeeid` attribute to the `<employee>` element, the `Append()` method of `Attributes` collection is used. The `Append()` method accepts an instance of the `XmlAttribute` class.

The `AppendChild()` method of the `XmlNode` class accepts another `XmlNode` and makes it a child of the node on which `AppendChild()` has been called. The code calls the `AppendChild()` method on the `<employee>` element and adds all the remaining four elements as its children.

Next, the code adds all the text nodes and CDATA section to their respective parents by using the same `AppendChild()` method.

Finally, the entire `<employee>` node is appended to the `DocumentElement`, that is, the `<employees>` root node. Because we added a new node to the document, the `Save()` method is needed to save the changed document to disk.

Using Helper Methods

In the preceding code, we frequently used two helper methods: `FillControls()` and `UpdateLabel()`. These methods are shown in Listing 2-17.

Listing 2-17. Helper Methods Used in the Application

```
private void FillControls()
{
    XmlNode node = doc.DocumentElement.ChildNodes[CurrentNodeIndex];
    comboBox1.Text = node.Attributes["employeeid"].Value;
    textBox1.Text = node.ChildNodes[0].InnerText;
    textBox2.Text = node.ChildNodes[1].InnerText;
    textBox3.Text = node.ChildNodes[2].InnerText;
    textBox4.Text = node.ChildNodes[3].InnerText;
    UpdateLabel();
}

private void UpdateLabel()
{
    label6.Text = $"Employee {(CurrentNodeIndex + 1)} of {doc.DocumentElement.ChildNodes.Count}";
}
```

The `FillControls()` method retrieves a reference to the `<employee>` node to be displayed. The index for this node is indicated by the `CurrentNodeIndex` variable. The `employeeid` is retrieved from the `Attributes` collection of the node and displayed in the combo box. Other text boxes are populated with the `InnerText` of `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>`, respectively.

The `UpdateLabel()` method simply sets the `Text` property of the navigation status label to the current employee index.

Dealing with Whitespace

You have learned how to read and write XML documents by using `XmlDocument` and associated classes. During various operations, we hardly bothered with whitespace. *Whitespace* includes characters such as space, tab, carriage return, and so on. By default, when you load the document (either via the `Load()` method or the `LoadXml()` method) or save the document (by using the `Save()` method), the `XmlDocument` class will ignore any whitespace. You can toggle this behavior by using a Boolean property called `PreserveWhiteSpace`. Setting this property to true will preserve the whitespace, whereas setting it to false will ignore it.

To see the difference the `PreserveWhiteSpace` property makes, let's create a simple application like the one shown in Figure 2-8.

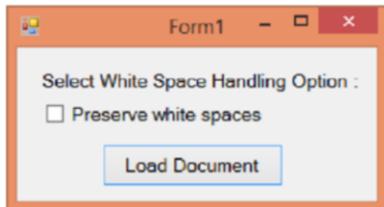


Figure 2-8. Importance of the `PreserveWhiteSpace` property

The application consists of a check box that allows you to toggle whether to preserve the whitespace. When you click the Load Document button, it simply loads the Employees.xml file by using the Load() method and displays the entire content in a message box.

The code inside the Click event handler of the Load Document button is shown in Listing 2-18.

Listing 2-18. Loading a Document

```
private void button1_Click(object sender, EventArgs e)
{
    XmlDocument doc = new XmlDocument();
    doc.PreserveWhitespace = checkBox1.Checked;
    doc.Load($"{Application.StartupPath}\\employees.xml");
    MessageBox.Show(doc.InnerXml);
}
```

The code creates an instance of the XmlDocument class and sets its PreserveWhitespace property to the property selected via the check box. That means if the user selects the check box, true will be assigned; otherwise, false will be assigned. Then the Employees.xml file is loaded by using the Load() method. The complete content of the file is retrieved by using the InnerXml property of the XmlDocument instance and displayed in a message box.

Figure 2-9 shows the message box that is displayed when you deselect the check box. In contrast, Figure 2-10 shows the message box when the check box is selected.

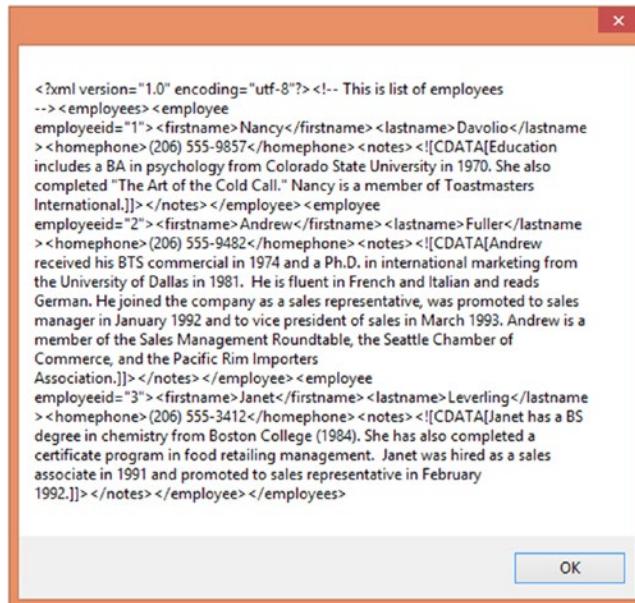


Figure 2-9. Output with the PreserveWhitespace property set to false

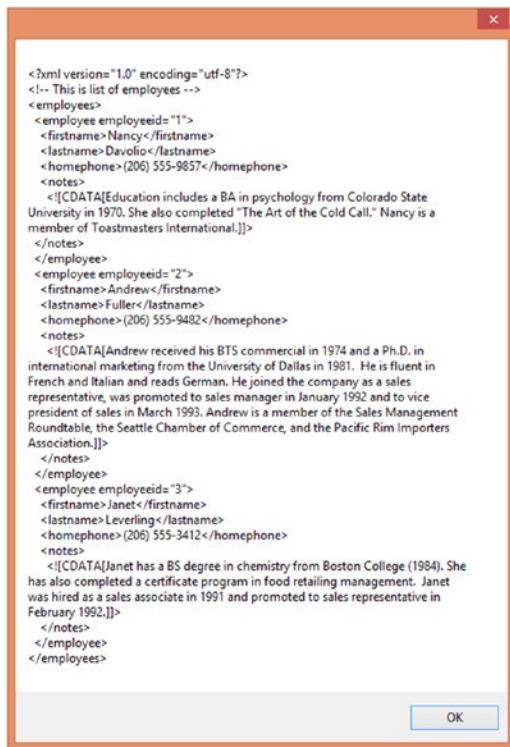


Figure 2-10. Output with the `PreserveWhitespace` property set to true

You can see the difference: the second message box shows that the whitespace is preserved.

Does the `PreserveWhitespace` property affect your parsing logic? The answer to this question is yes. To illustrate the effect of this property on the parsing of the document, let's modify the preceding application as shown in Listing 2-19.

Listing 2-19. Effect of the `PreserveWhitespace` Property

```

private void button1_Click(object sender, EventArgs e)
{
  XmlDocument doc = new XmlDocument();
  doc.PreserveWhitespace = checkBox1.Checked;
  doc.Load($"{Application.StartupPath}\\employees.xml");
  MessageBox.Show($"Employee node contains {doc.DocumentElement.ChildNodes.Count} child nodes");
}

```

The preceding code is almost identical to the previous example, but this time, the message box shows the total number of child nodes of the document element, that is, the root node `<employees>`. See Figures 2-11 and 2-12 for the resulting message boxes with the `PreserveWhitespace` property set to false and true, respectively.

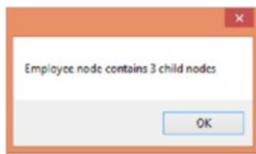


Figure 2-11. Result when the `PreserveWhitespace` property is false

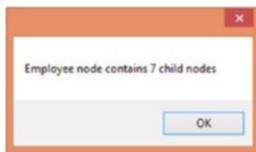


Figure 2-12. Result when the `PreserveWhitespace` property is true

Surprised? We have three `<employee>` elements in our document. That means the `<employees>` node has three child nodes. The message box from Figure 2-11 is consistent with this fact. However, when you set the `PreserveWhitespace` property to true, the message box shows that the `<employees>` element has seven child nodes. Preserving whitespace added four child nodes to the `<employees>` element. These extra nodes are of type `XmlWhiteSpace`. If you are accessing various nodes by their indexes, toggling whitespace can cause your logic to fail. There is one more class related to whitespace: `XmlSignificantWhiteSpace`. The `XmlSignificantWhiteSpace` class represents whitespace between markup in a mixed content node.

It is important to understand the difference between `XmlWhiteSpace` and `XmlSignificantWhiteSpace`. Consider the markup shown in Listing 2-20.

Listing 2-20. Understanding the Difference Between the `XmlWhiteSpace` and `XmlSignificantWhiteSpace` Classes

```
<?xml version="1.0" ?>
<root>
  <fullname>Nancy Davolio</fullname>
  <address>
    507 - 20th Ave. E. Apt. 2A
    Seattle,
    WA 98122
    USA
  </address>
</root>
```

In the markup shown in Listing 2-20, there are several areas of whitespace. First, there is whitespace between tags such as `<root>`, `<fullname>`, and `<address>`. Remember that in XML, carriage returns and line feeds are also considered whitespace. The whitespace between various elements is used mainly to improve readability of the document and is represented by the `XmlWhiteSpace` class. Second, there is whitespace embedded in the content of the `<address>` node. For example, there is a carriage return and line feed after the text `Seattle` as well as `WA 98122`. This type of whitespace is represented by the `XmlSignificantWhiteSpace` class.

Dealing with Namespaces

The concept of XML namespaces is analogous to .NET namespaces. XML namespaces allow you to identify elements as part of a single group (a namespace) by uniquely qualifying element and attribute names used in an XML document. Each namespace is identified by a Uniform Resource Identifier (URI). This allows developers to combine information from different data structures in a single XML document without causing ambiguity and confusion among element names.

For example, assume that you have two XML fragments, one related to employees and another related to customers. Further assume that both fragments contain a tag called `<name>`. The problem is that when you mix them together, you have ambiguity for the `<name>` tag. XML namespaces come in handy in such situations.

To see how .NET Framework provides support for XML namespaces, we will modify `Employees.xml`, as shown in Listing 2-21.

Listing 2-21. XML Document with Namespaces

```
<?xml version="1.0" encoding="utf-8" ?>
<!-- This is list of employees -->
<emp:employees xmlns:emp="http://localhost/employees">
    <emp:employee employeeid="1">
        <emp:firstname>Nancy</emp:firstname>
        <emp:lastname>Davolio</emp:lastname>
        <emp:homephone>(206) 555-9857</emp:homephone>
        <emp:notes>
            <![CDATA[Education includes a BA in psychology from Colorado State University
            in 1970. She also completed "The Art of the Cold Call." Nancy is a member of
            Toastmasters International.]]>
        </emp:notes>
    </emp:employee>
    <emp:employee employeeid="2">
        <emp:firstname>Andrew</emp:firstname>
        <emp:lastname>Fuller</emp:lastname>
        <emp:homephone>(206) 555-9482</emp:homephone>
        <emp:notes>
            <![CDATA[Andrew received his BTS commercial in 1974 and a Ph.D.
            in international marketing from the University of Dallas in 1981. He is fluent
            in French and Italian and reads German. He joined the company as a sales
            representative, was promoted to sales manager in January 1992 and to vice president
            of sales in March 1993. Andrew is a member of the Sales Management Roundtable, the
            Seattle Chamber of Commerce, and the Pacific Rim Importers Association.]]>
        </emp:notes>
    </emp:employee>
    <emp:employee employeeid="3">
        <emp:firstname>Janet</emp:firstname>
        <emp:lastname>Leverling</emp:lastname>
        <emp:homephone>(206) 555-3412</emp:homephone>
        <emp:notes>
            <![CDATA[Janet has a BS degree in chemistry from Boston College (1984). She has also
            completed a certificate program in food retailing management. Janet was hired as a
            sales associate in 1991 and promoted to sales representative in February 1992.]]>
        </emp:notes>
    </emp:employee>
</emp:employees>
```

It's the same document, but we added a namespace to it. Look at the markup shown in bold. In the root element `<employees>`, we specified an XML namespace called `emp` with a URI `http://localhost/employees`. Though it is a common practice to use URLs as namespace URIs, any unique string would work. Note how all the tag names are prefixed with `emp`. You can access namespace details by using three properties of the `XmlNode` class: `NamespaceURI`, `Prefix`, and `LocalName`.

To illustrate how these properties are used, we will develop an application like the one shown in Figure 2-13.

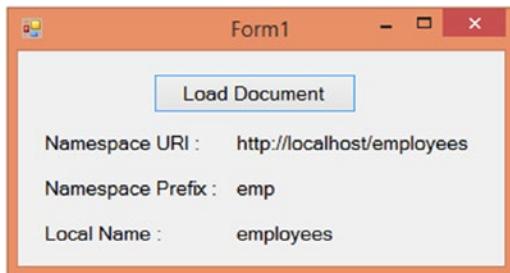


Figure 2-13. Retrieving namespace details

The application loads our new version of `Employees.xml` and extracts the `NamespaceURI`, `Prefix`, and `LocalName` properties of the document element. The namespace details are shown in labels. Listing 2-22 shows the `Click` event handler of the Load Document button.

Listing 2-22. Retrieving Namespace Details

```
private void button1_Click(object sender, EventArgs e)
{
    XmlDocument doc = new XmlDocument();
    doc.Load($"{Application.StartupPath}\\employees.xml");
    label4.Text = doc.DocumentElement.NamespaceURI;
    label5.Text = doc.DocumentElement.Prefix;
    label6.Text = doc.DocumentElement.LocalName;
}
```

The code loads the `Employees.xml` file by using the `Load()` method. It then simply retrieves the value of the `NamespaceURI`, `Prefix`, and `LocalName` properties. One thing to note is that these three properties are read-only properties. If you want to write these details, you must supply them while creating attributes, elements, and nodes from the `XmlDocument` class. Methods of the `XmlDocument` class, such as `CreateElement()` and `CreateAttribute()`, have appropriate overloads that allow you to specify namespace details.

Understanding Events of the `XmlDocument` Class

Whenever you modify an XML document, the `XmlDocument` class raises several events. These events follow a pre-and post-pattern. Pre-events are raised prior to the actual operation, whereas post-events are raised after the operation is over. These events are summarized in Table 2-3.

Table 2-3. Events of the XmlDocument Class

Event Name	Description
NodeChanging	This event is raised when the value of a node belonging to this document is about to be changed.
NodeChanged	This event is raised when the value of a node belonging to this document has been changed.
NodeRemoving	This event is raised when a node belonging to this document is about to be removed from the document.
NodeRemoved	This event is raised when a node belonging to this document has been removed from its parent.
NodeInserting	This event is raised when a node belonging to this document is about to be inserted into another node.
NodeInserted	This event is raised when a node belonging to this document has been inserted into another node.

Each of the events specified in the preceding table receives an event argument parameter of type `XmlNodeChangedEventArgs`. The `XmlNodeChangedEventArgs` class provides several properties. Some of them are listed in Table 2-4.

Table 2-4. Properties of the XmlNodeChangedEventArgs Class

Property	Description
Action	Supplies information about the action that is causing the node to change. This property is an enumeration of type <code>XmlNodeChangedAction</code> . Possible values include Change, Remove, and Insert.
OldParent	Returns the parent <code>XXmlNode</code> of the node being changed prior to the operation.
NewParent	Returns the parent <code>XXmlNode</code> of the node being changed after the operation.
OldValue	Returns the value of the node prior to the operation.
NewValue	Returns the value of the node after the operation is complete.
Node	Returns an <code>XXmlNode</code> object representing the node being affected.

To see some of these events in action, we will modify the same employee data-entry application that we developed previously.

Modify the `Form_Load` event handler as shown in Listing 2-23.

Listing 2-23. Attaching Event Handlers

```
private void Form1_Load(object sender, EventArgs e)
{
    doc.Load($"{Application.StartupPath}\\employees.xml");

    doc.NodeChanged += new XmlNodeChangedEventHandler(doc_NodeChanged);
    doc.NodeInserted += new XmlNodeChangedEventHandler(doc_NodeInserted);
    doc.NodeRemoved += new XmlNodeChangedEventHandler(doc_NodeRemoved);
```

```

foreach (XmlNode node in doc.DocumentElement.ChildNodes)
{
    comboBox1.Items.Add(node.Attributes["employeeid"].Value);
}
FillControls();
}

```

Note the lines marked in bold. The code attaches event handlers to the `NodeChanged`, `NodeRemoved`, and `NodeInserted` events, respectively. These events are of delegate type `XmlNodeChangedEventHandler`.

The code in Listing 2-24 shows these event handlers.

Listing 2-24. Handling Events of the XmlDocument Class

```

void doc_NodeRemoved(object sender, XmlNodeChangedEventArgs e)
{
    MessageBox.Show($"Node {e.Node.Name} removed successfully!");
}

void doc_NodeInserted(object sender, XmlNodeChangedEventArgs e)
{
    MessageBox.Show($"Node {e.Node.Name} added successfully!");
}

void doc_NodeChanged(object sender, XmlNodeChangedEventArgs e)
{
    MessageBox.Show($"Node {e.Node.Name} changed successfully!");
}

```

The code in each event handler simply displays the node being affected in a message box. To test these events, you need to run the application and try updating, deleting, and adding new employees. You will find that with every such operation, the `NodeChanged`, `NodeRemoved`, and `NodeInserted` events are raised. Figure 2-14 shows a sample run of the application.

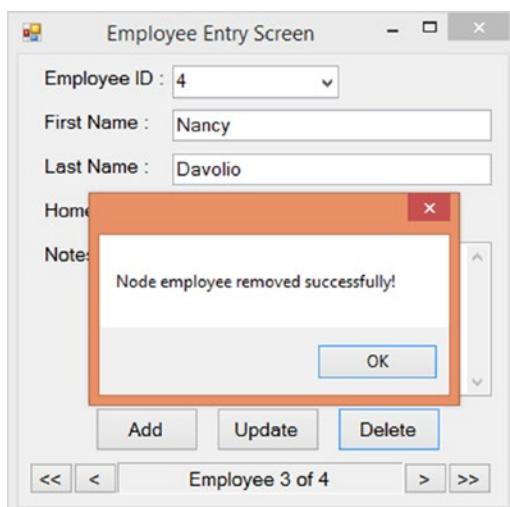


Figure 2-14. Handling events of the XmlDocument class

Summary

This chapter presented a detailed examination of the `XmlDocument` class—the .NET Framework's DOM parser. You worked with several other classes, including `XmlNode`, `XElement`, `XmlAttribute`, and `XmlText`. You learned how to load XML documents, how to navigate through them, how to read the content, and finally how to modify them. You also learned how whitespace and namespaces can be dealt with. Finally, you handled various events of `XmlDocument` that are raised when you change the document in some way.

You can build on what you have learned so far. For example, you can create your own custom extensions of `XmlDocument` and other classes by inheriting from them. Though the need to do so is rare, this task can be accomplished by inheriting from these classes and adding extra properties and methods.

CHAPTER 3



Reading and Writing XML Documents

Chapter 2 gave you a detailed understanding of the .NET Framework's DOM parser, that is, the `XmlDocument` class. You also learned when to use DOM parsers. In this chapter, you are going to learn about XML reader and writer classes. The topics discussed include the following:

- Using reader and writer classes
- Knowing when to use these classes instead of DOM
- Reading XML documents by using the `XmlTextReader` class
- Writing XML documents by using the `XmlTextWriter` class
- Dealing with non-textual data

What Are XML Readers and Writers?

DOM-based parsers are best suited for modifying XML documents that are small. However, with huge XML documents, DOM access can pose problems in terms of memory footprint and performance. In such cases, an alternative must be adopted so that we can read and write XML documents without these limitations. Traditionally, event-based parsers based on the SAX specifications were used to deal with such scenarios. The .NET answer, however, is a bit different.

The .NET Framework provides a pull-model parser in the form of a class called `XmlReader`. `XmlReader` provides read-only access to XML documents in a forward-only fashion. Though SAX and `XmlReader` sound similar, they behave differently. Any SAX-based parser essentially raises events as various parts of the XML document are encountered. Thus it works on a push model. On the other hand, the `XmlReader` class allows you to iterate through the document and access the required content rather than raising events. Thus it uses a pull model. As you will see later, this pull model is more flexible from a development point of view. The `XmlReader` class does not load the entire document in memory, resulting in a small memory footprint. Because it is read-only, it is faster too.

Just as `XmlReader` allows you to read XML documents, a class called `XmlWriter` allows you to write XML documents. Like `XmlReader`, `XmlWriter` also uses a forward-only model. However, it offers write-only functionality.

The `XmlReader` and `XmlWriter` classes are abstract classes. That means you will not be able to instantiate and use them directly in your code. Fortunately, the `System.Xml` namespace contains two ready-to-use classes that inherit from these base classes. Those classes are `XmlTextReader` and `XmlTextWriter`. The former inherits from `XmlReader`, whereas the latter inherits from `XmlWriter`.

When to Use Readers and Writers

In the previous section, you learned that DOM parsers are a poor choice when working with huge XML documents. In general, you can say that `XmlReader` is better suited when

- You need to only read the document.
- The document is huge.
- You need to keep the memory footprint small.
- You want to work with many XML documents that are reasonably large in size.
- You do not want to access various parts of the document randomly.

Similarly, `XmlWriter` is better suited when

- You want to only write content.
- You want to keep the memory footprint small.
- You are writing huge XML documents and looking for better performance.

Reader Classes

As you've seen, the `XmlReader` is an abstract class. That means you cannot instantiate it directly in your applications; you must inherit from it to make any use of it. Fortunately, the .NET Framework provides three implementations of the `XmlReader` class that you can use in your code. These implementations are discussed briefly in this section.

The `XmlTextReader` Class

The `XmlTextReader` class can be used to parse XML documents. This class has very fast parsing abilities. It checks that the underlying documents are well formed but does not validate them against a DTD or Schema.

The `XmlValidatingReader` Class

The `XmlValidatingReader` class can validate an XML document against a DTD or Schema.

The `XmlNodeReader` Class

The `XmlNodeReader` class allows you to read XML data from the DOM tree. The constructor of `XmlNodeReader` takes a parameter of type `XmlNode`. This `XmlNode` can be obtained as a result of an XPath query or directly from a DOM document. In terms of properties and methods, the `XmlNodeReader` class closely resembles the `XmlTextReader` class.

Reading XML Documents Using XmlTextReader

In this section, you learn the following:

- How to open XML documents by using the `XmlTextReader` class
- How to read and access the content
- How to deal with whitespace
- How to work with name tables
- How to deal with namespaces

Let's begin by opening XML documents. Throughout our examples, we will be using the same `Employees.xml` file that we used earlier in the book.

Opening XML Documents

To illustrate how XML documents can be opened for reading, we will develop a Windows Forms application like the one shown in Figure 3-1.

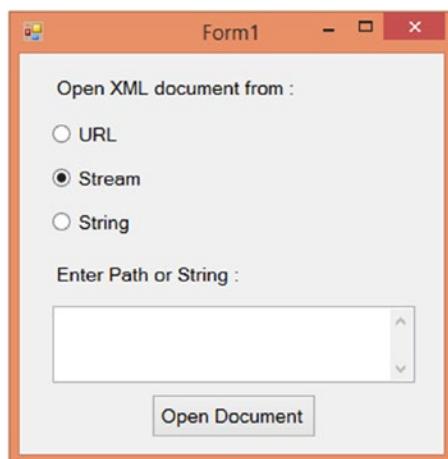


Figure 3-1. Reading XML documents by using `XmlTextReader`

The application allows you to choose the location from which the document is to be opened. The possible locations are URL, stream, or string. Depending on the choice, you need to enter the URL, filename, or XML string in the text box and click the Open Document button. Clicking the Open Document button opens the document and displays a success message box.

The `XmlReader` class can read an XML document from either a URL or a stream. The stream can be any kind of stream, such as a `FileStream` or `MemoryStream`. To read a string, first you need to read the string into a `MemoryStream` and then feed this `MemoryStream` to the `XmlReader` class. The code from Listing 3-1 shows these three techniques.

Listing 3-1. Loading an XML Document in XmlTextReader

```

private void button1_Click(object sender, EventArgs e)
{
    XmlTextReader reader;

    if (radioButton1.Checked)
    {
        reader = new XmlTextReader(textBox1.Text);
    }

    if (radioButton2.Checked)
    {
        FileStream stream=File.OpenRead(textBox1.Text);
        reader = new XmlTextReader(stream);
        //some processing code
        stream.Close();
        reader.Close();
    }

    if (radioButton3.Checked)
    {
        MemoryStream ms=new MemoryStream();
        byte[] data=ASCIIEncoding.ASCII.GetBytes(textBox1.Text);
        ms.Write(data,0,data.Length);
        reader = new XmlTextReader(ms);
        //some processing code
        ms.Close();
        reader.Close();
    }

    MessageBox.Show("XML Document Opened Successfully!");
}

```

Note Make sure to import the `System.Xml` and `System.IO` namespaces before writing the preceding code. The `XmlTextReader` class resides in the `System.Xml` namespace, and the `MemoryStream` class resides in the `System.IO` namespace.

The code declares a variable of type `XmlTextReader`. It then checks to see which radio button has been selected. If the user wants to use a URL, a new instance of `XmlTextReader` is created by passing the URL in the constructor.

If the user decides to read the file from disk, it is first read into a stream. This is done by using the `OpenRead()` method of the `File` class. The `OpenRead()` method opens the specified file in read-only mode. The resulting `FileStream` is then passed in the constructor of the `XmlTextReader` class.

The third condition reads the string into `MemoryStream`. Note the use of the `GetBytes()` method to convert a string into a byte array. The resulting byte array is written to the `MemoryStream` object. Finally, this `MemoryStream` instance is supplied to the constructor of the `XmlTextReader` class.

A message box simply displays a message confirming that the document was opened successfully.

Reading Attributes, Elements, and Values

In this section, we are going to develop a Windows Forms application that will display a tree of various elements and their values. In the process, you will learn how to read attributes, elements, and text nodes from an XML document by using the `XmlTextReader` class.

The application is shown in Figure 3-2.

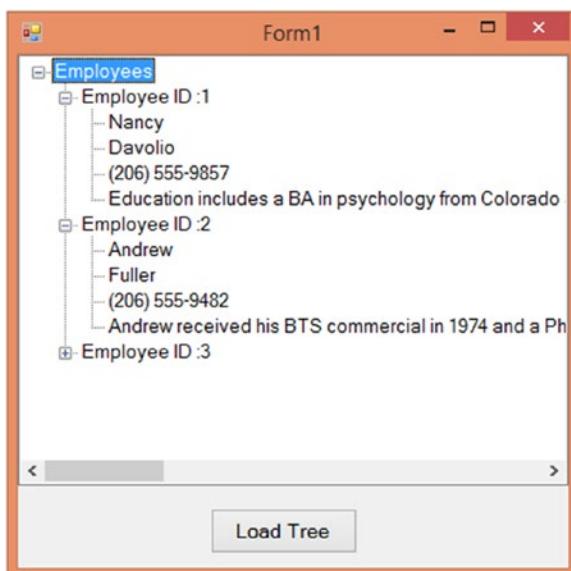


Figure 3-2. Reading an XML document by using `XmlTextReader`

The application consists of a `TreeView` control and a `Button` control. Clicking the Load Tree button displays the entire tree of nodes in the tree view as shown.

The core logic goes in the `Click` event handler of the Load Tree button and is shown in Listing 3-2.

Listing 3-2. Loading the Tree

```
private void button1_Click(object sender, EventArgs e)
{
    XmlTextReader reader =
        new XmlTextReader($"{Application.StartupPath}\\employees.xml");
    reader.WhiteSpaceHandling = WhiteSpaceHandling.None;
    TreeNode employeeNode=null;
    TreeNode rootNode = null;

    while (reader.Read())
    {
        if (reader.NodeType == XmlNodeType.Element)
        {
            if (reader.Name == "employees")
            {
                rootNode = treeView1.Nodes.Add("Employees");
            }
        }
    }
}
```

```

if (reader.Name == "employee")
{
    string employeeid = reader.GetAttribute("employeeid");
    employeenode = new TreeNode("Employee ID :" + employeeid);
    rootnode.Nodes.Add(employeenode);
}

if (reader.Name == "firstname")
{
    string firstname = reader.ReadElementString();
    TreeNode node = new TreeNode(firstname);
    employeenode.Nodes.Add(node);
}

if (reader.Name == "lastname")
{
    reader.Read();
    string lastname = reader.Value;
    TreeNode node = new TreeNode(lastname);
    employeenode.Nodes.Add(node);
}

if (reader.Name == "homephone")
{
    string homephone = reader.ReadElementString();
    TreeNode node = new TreeNode(homephone);
    employeenode.Nodes.Add(node);
}

if (reader.Name == "notes")
{
    string notes = reader.ReadElementString();
    TreeNode node = new TreeNode(notes);
    employeenode.Nodes.Add(node);
}

reader.Close();
}

```

The code creates an instance of the `XmlTextReader` class by passing the path of the XML file. The `WhitespaceHandling` property of `XmlTextReader` governs the behavior of the reader while reading whitespace. This property is an enumeration of type `WhitespaceHandling` and has three possible values: `All`, `None`, or `Significant`. We set `WhitespaceHandling` to ignore any whitespace. This will simplify our coding.

A while loop repeatedly calls the `Read()` method of `XmlTextReader`. The `Read()` method reads the next node from the file and returns true if the next node can be read successfully; otherwise, it returns false.

Inside the while loop, the code retrieves the type of node by using the `NodeType` property of the `XmlTextReader` class. The `NodeType` property is an enumeration of type `XmlNodeType` and can have values such as `Attribute`, `CDATA`, `Comment`, `Element`, `EndElement`, `Text`, `Whitespace`, `SignificantWhitespace`, and so on. Note that the start and end elements are represented separately. This is because, while scanning the

document, the `XmlTextReader` class reads start elements (for example, `<employee>`) and end elements (for example, `</employee>`) separately. In our example, we are interested only in start elements and therefore the `if` condition checks only for a node type of `Element`.

The code then checks the name of each element. This is done by checking the `Name` property of the `XmlTextReader` class and executing code depending on the element name:

- If the element name is `employees`, the code adds the root node of the `TreeView` control.
- If the element name is `employee`, the code retrieves the `employeeid` attribute. To retrieve attribute values, `XmlTextReader` provides a method called `GetAttribute()`, which accepts the name of the attribute whose value is to be retrieved and returns the value as a string. A tree node is then added for this `employee`.
- If the element name is `firstname`, the text value inside it needs to be retrieved. This is done with the help of the `ReadElementString()` method, which returns the text content within the current element. For us it will return the first name of the `employee`. Note that you can also use `ReadElementContentAsString()` method for this purpose.
- The next `if` condition contains a variation on reading element values. It also illustrates the cursor-oriented model of `XmlTextReader`. When this `if` condition is triggered, the `XmlTextReader` is pointing to the `<lastname>` element. When we call the `Read()` method again, the cursor moves to the text node inside the `<lastname>` element. The `Value` property of `XmlTextReader` then returns the value of the text node.
- The values of the `homephone` and `notes` elements are read along the same lines.

Finally, the `XmlTextReader` is closed by using its `Close()` method.

Improving Performance by Using Name Tables

Whenever `XmlTextReader` parses any XML file, it creates a list of element names found in that document. This list is called a *name table*. Imagine that you are parsing dozens of separate files that have the same structure as `Employees.xml`. That means the `XmlTextReader` class needs to generate the same name table again and again. You can improve the efficiency of this process by supplying a ready-made name table, represented by the `XmlNameTable` class, for further parsing. The `XmlNameTable` class is an abstract class, but the .NET Framework provides a class called `NameTable` that inherits from it. You can therefore use this `NameTable` class in your code.

The code fragment in Listing 3-3 will use the name tables clear.

Listing 3-3. Using Name Tables

```
NameTable table = new NameTable();
XmlTextReader reader1 =
    new XmlTextReader("${Application.StartupPath}\\\employees1.xml",table);
//read using reader1 here
XmlTextReader reader2 =
    new XmlTextReader("${Application.StartupPath}\\\employees2.xml",table);
XmlTextReader reader3 =
    new XmlTextReader("${Application.StartupPath}\\\employees3.xml",table);
//process further
```

The code creates a new instance of the `NameTable` class, which will naturally be empty. Then an instance of `XmlTextReader` is created. This time the constructor takes two parameters: a filename and a `NameTable`. When you read the XML document for the first time, that is, using `reader1`, the supplied `NameTable` instance is populated. That means we have a `NameTable` ready for use. The same `NameTable` is supplied as a parameter to `reader2` and `reader3`; they will in turn use this ready-made `NameTable`, thus improving the efficiency of the code.

Dealing with Namespaces

The `XmlTextReader` class has the same three XML namespace-related properties as the `XmlNode` class. The properties are `NamespaceURI`, `Prefix`, and `LocalName`. Their meaning is the same as discussed in Chapter 2.

Note In the example you just developed, a concrete implementation of `XmlReader` in the form of `XmlTextReader` was used. You can also create a reader using the `Create()` method of the `XmlReader` class. You will learn about the `Create()` method in Chapter 5.

Moving Between Elements

In the previous example, you learned how to navigate through and read an XML document by using `XmlTextReader`. There are some additional methods of `XmlTextReader` that allow you to move between elements and read the content. This section presents these methods.

The `ReadSubTree()` Method

The `ReadSubTree()` method reads sub-nodes of the current node and returns the sub-tree as another `XmlReader` instance. This method is useful when you are parsing huge documents but want to work with a small section at a time. Figure 3-3 shows pictorially how this method works.

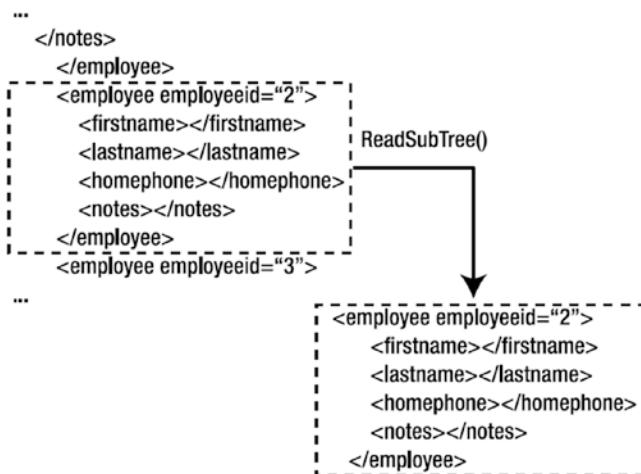


Figure 3-3. Using the `ReadSubTree()` method

From the figure, you can see that if you call `ReadSubTree()` when your `XmlTextReader` is on an `<employee>` node of the document, the `ReadSubTree()` method returns another `XmlReader` containing that `<employee>` node and all its child nodes (that is, the sub-tree of the `<employee>` node).

The ReadToDescendant() Method

The `ReadToDescendant()` method advances the `XmlTextReader` to the next occurrence of the specified child node. This method comes in handy when you want to jump to a specific node rather than sequentially moving there. Figure 3-4 shows how this method works.

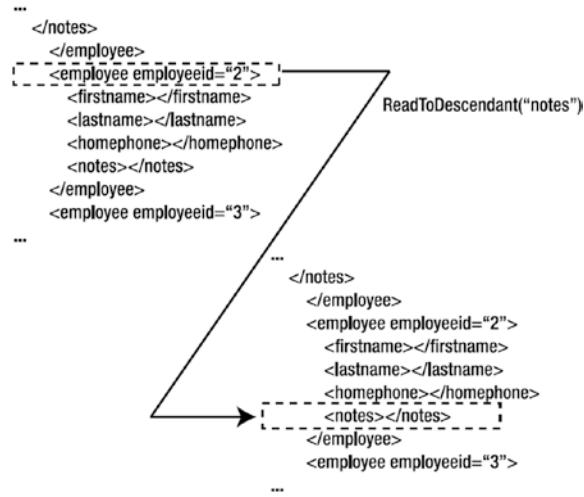


Figure 3-4. Using the `ReadToDescendant()` method

As shown in Figure 3-4, if you call the `ReadToDescendant()` method when you are on an `<employee>` node and specify `notes` as the target element, your reader jumps to the next `<notes>` element.

The ReadToFollowing() Method

The `ReadToFollowing()` method is very similar to the `ReadToDescendant()` method, with one difference. The `ReadToDescendant()` method can jump to the specified element only if it is a descendant of the current node, whereas the `ReadToFollowing()` method jumps to the first occurrence of the specified element, be it a descendant or not.

Note Notice the difference between the `ReadToDescendant()` and `ReadToFollowing()` methods.

Assuming that you are on the `<employee>` node of the second employee and wish to jump to the `<notes>` node of the same employee, you would use the `ReadToDescendant()` method. On the other hand, if you are on the `<firstname>` node of the second employee and wish to jump to the next occurrence of the `<firstname>` node, you would use the `ReadToFollowing()` method.

The ReadToNextSibling() Method

The `ReadToNextSibling()` method moves the reader from the current element to the next element at the same level. Figure 3-5 shows how this method works.

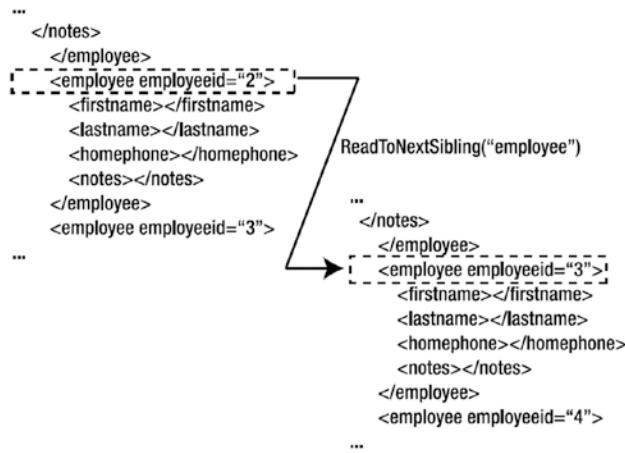


Figure 3-5. Using the `ReadToNextSibling()` method

As you can see in Figure 3-5, if you call `ReadToNextSibling()` when the reader is on the second `<employee>` node, the reader will jump to the third `<employee>` node because they are sibling nodes.

The Skip() Method

The `Skip()` method skips the child elements and jumps directly to the next element. `Skip()` comes in handy when you want to bypass child nodes depending on a certain condition. Figure 3-6 shows how this method works.

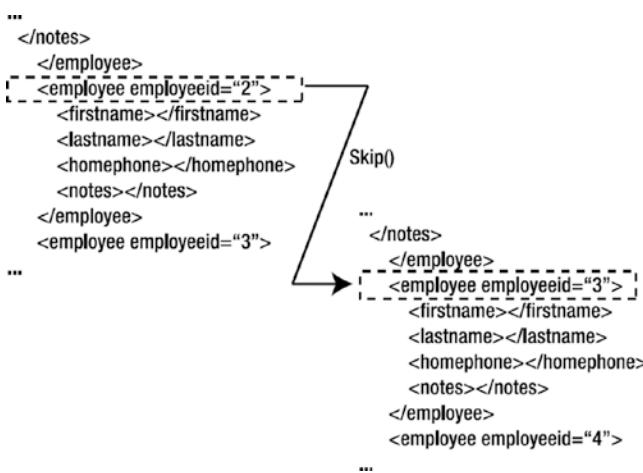


Figure 3-6. Using the `Skip()` method

Note the difference between the `ReadToNextSibling()` method and the `Skip()` method. The former advances the reader to the next sibling element, whereas the latter advances the reader to the next possible element (not necessarily a sibling node) after bypassing the child nodes.

Moving Between Attributes

The `XmlTextReader` class also provides four methods for moving between attributes. These methods, which are useful only for element nodes, are as follows:

- The `MoveToAttribute()` method accepts the index or name of the attribute to navigate to and moves the reader to the attribute.
- The `MoveToFirstAttribute()` method takes the reader to the first attribute of the current element.
- The `MoveToNextAttribute()` method moves the reader to the next attribute of the current element.
- The `MoveToElement()` method moves the reader back to the element node whose attributes were just read.

Figure 3-7 shows how all these methods work.

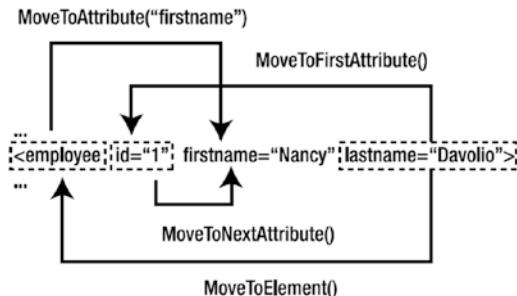


Figure 3-7. Moving between attributes

As you can see in Figure 3-7, if you call `MoveToAttribute()` by passing `firstname` as the parameter, the reader moves to the `firstname` attribute. When you are on the `lastname` attribute, calling `MoveToFirst()` will take the reader to the `id` attribute. Calling `MoveToNextAttribute()` when the reader is on the `id` attribute will advance the reader to the `firstname` attribute. Finally, calling `MoveToElement()` from any attribute will take the reader back to the `<employee>` element.

Reading Content

In our previous example, we used the `Value` property and the `ReadElementString()` method to read content from an element. In this section, you are going to see a few more ways to read the content.

The ReadInnerXml() Method

The `ReadInnerXml()` method reads all the XML content inside the current node and returns it as a string. The returned string does not contain the current node markup. For example, if you call `ReadInnerXml()` when your reader is on the first `<employee>` element, the method will return the markup as shown in Listing 3-4.

Listing 3-4. Result of the `ReadInnerXml()` Method

```
<firstname>Nancy</firstname>
<lastname>Davolio</lastname>
<homephone>(206) 555-9857</homephone>
<notes>
<![CDATA[Education includes a BA in psychology from Colorado State University in 1970.
She also completed "The Art of the Cold Call." Nancy is a member of Toastmasters
International.]]>
</notes>
```

The ReadOuterXml() Method

The `ReadOuterXml()` method is similar to the `ReadInnerXml()` method, but the difference is that it also includes the markup of the current element. For example, if you call `ReadOuterXml()` while the reader is on the first `<employee>` element, `ReadOuterXml()` will return the markup as shown in Listing 3-5.

Listing 3-5. Result of the `ReadOuterXml()` Method

```
<employee employeeid="1">
  <firstname>Nancy</firstname>
  <lastname>Davolio</lastname>
  <homephone>(206) 555-9857</homephone>
  <notes>
    <![CDATA[Education includes a BA in psychology from Colorado State University in 1970.
    She also completed "The Art of the Cold Call." Nancy is a member of Toastmasters
    International.]]>
  </notes>
</employee>
```

The ReadString() Method

The `ReadString()` method reads the contents of an element or a text node as a string. It simply returns all the text from the element until any markup is encountered. For example, look at the XML markup shown here:

```
<node1>
  <node2>
    Hello World <node3>This is some text</node3>
  </node2>
</node1>
```

If you call `ReadString()` when the reader is on `<node2>`, `ReadString()` will return `Hello World` and not the remaining markup from `<node3>`.

Writing XML Documents Using XmlTextWriter

In the previous sections, you learned how `XmlTextReader` can be used to read XML documents in a sequential fashion. Reading XML documents is just half of the story; often you also need to write XML documents.

The counterpart of `XmlTextReader` is another class called `XmlTextWriter`. The `XmlTextWriter` class allows you to quickly serialize XML documents to a file or any stream. The `XmlTextWriter` class inherits from an abstract class: `XmlWriter`. In this section, you will learn how this class can be used to write XML documents.

To see the `XmlTextWriter` class in action, you will build a Windows Forms application like the one shown in Figure 3-8.



Figure 3-8. Using the `XmlTextWriter` class

The application allows you to export data from any table of a SQL Server database into an XML file. As shown in Figure 3-8, the application accepts a database connection string, a table name to export, and the destination XML filename where the data is to be exported. The two radio buttons allow you to select whether all the columns are to be exported as elements or attributes in the resultant document. Clicking the Export Data button exports the data to the specified file.

The code needs to import the following namespaces:

```
using System.Data.SqlClient;
using System.Xml;
```

The `System.Data.SqlClient` namespace represents the SQL Server Data Provider of the .NET Framework and supplies classes related to data access such as `SqlConnection` and `SqlCommand`.

The Click event handler of the Export Data button contains the code shown in Listing 3-6.

Listing 3-6. Exporting Data

```
private void button1_Click(object sender, EventArgs e)
{
    SqlConnection cnn = null;
    SqlCommand cmd = null;
    SqlDataReader reader = null;
    XmlTextWriter writer = null;

    try
    {
        cnn = new SqlConnection(textBox1.Text);
        cmd = new SqlCommand();
        cmd.Connection = cnn;
        cmd.CommandText = $"select * from {textBox2.Text}";
        cnn.Open();
        reader = cmd.ExecuteReader();
        writer = new XmlTextWriter(textBox3.Text, null);
        writer.WriteStartDocument();
        writer.WriteComment($"File exported on {DateTime.Now}");
        writer.WriteStartElement("table");
        while (reader.Read())
        {
            if (radioButton1.Checked)
            {
                writer.WriteStartElement("row");
                for (int i = 0; i < reader.FieldCount; i++)
                {
                    writer.WriteStartElement(reader.GetName(i));
                    writer.WriteString(reader.GetValue(i).ToString());
                    writer.WriteEndElement();
                }
                writer.WriteEndElement();
            }
            else
            {
                writer.WriteStartElement("row");
                for (int i = 0; i < reader.FieldCount; i++)
                {
                    writer.WriteAttributeString(reader.GetName(i),
                        reader.GetValue(i).ToString());
                }
                writer.WriteEndElement();
            }
        }
        writer.WriteEndElement();
    }
    catch (Exception ex)
    {
        MessageBox.Show(ex.Message);
    }
}
```

```

finally
{
    writer.Close();
    reader.Close();
    cnn.Close();
}
}

```

The code creates an instance of the `SqlConnection` class by passing a database connection string as the parameter. The `SqlConnection` class represents a database connection. In order to execute queries against a database, a `SqlCommand` object is created. The `Connection` property of `SqlCommand` represents the `SqlConnection` object through which the queries are to be executed. The `CommandText` property indicates the SQL query that is to be executed. In our example, we need to form a `SELECT` query by concatenating the name of the table as entered by the user (of course, in a real-world application, you should avoid forming queries this way due to security reasons).

The code then opens the connection with the help of the `Open()` method of `SqlConnection`. The `ExecuteReader()` method fires the `SELECT` statement as indicated by the `CommandText` property and returns a `SqlDataReader` object. The `SqlDataReader` object is like a read-only and forward-only cursor and allows you to iterate through the result set.

The code then proceeds to create an instance of the `XmlTextWriter` class, which can write directly to a disk file or to any stream. In our example, we write the data directly to the specified disk file. The second parameter of the constructor is the encoding of the data to be written. If this parameter is null, the `XmlTextWriter` writes the data as UTF-8 (Unicode Transformation Format, 8-bit encoding form) and omits the `encoding` attribute from the XML processing instruction. After the `XmlTextWriter` instance is ready, the actual writing process begins.

When the user selects to export all the columns as XML elements, the resultant document will bear the structure shown in Figure 3-9.

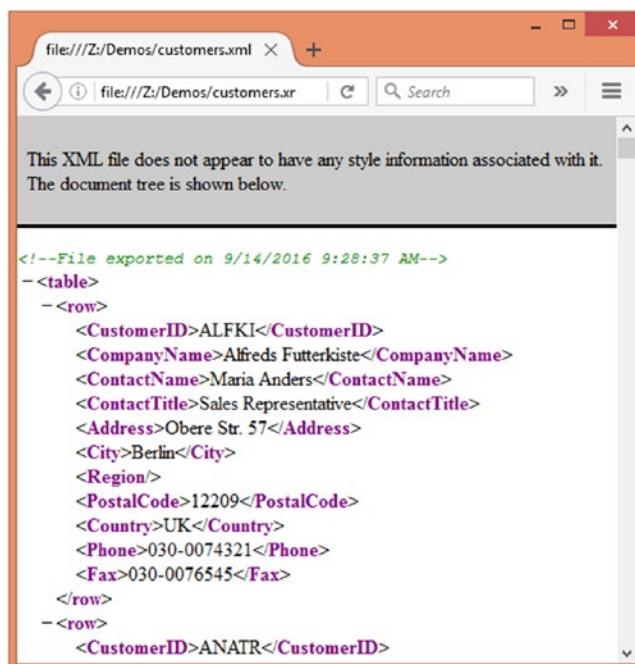
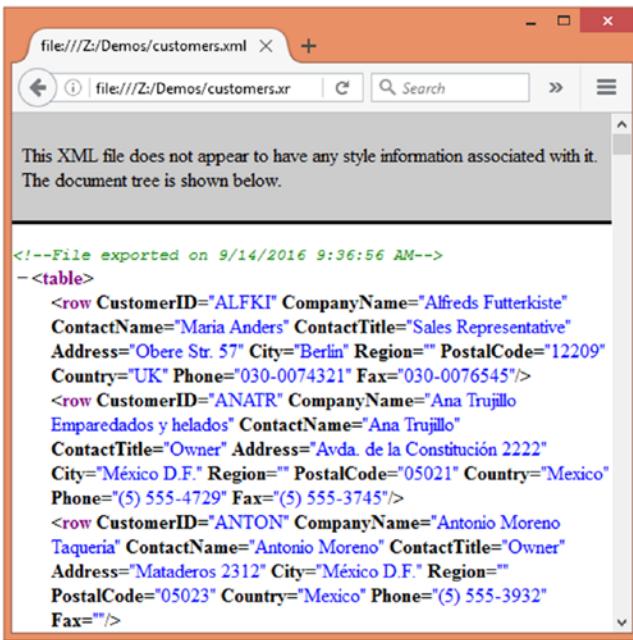


Figure 3-9. Columns exported as elements

The root element is `<table>`, which contains one or more `<row>` elements. Each `<row>` element further contains child elements, depending on the number of columns in the table. The child elements assume the same name as the database column name.

Similarly, when the user opts to export all the columns as attributes, the resultant document will bear the structure shown in Figure 3-10.



This XML file does not appear to have any style information associated with it.
The document tree is shown below.

```

<!--File exported on 9/14/2016 9:36:56 AM-->
-<table>
  <row CustomerID="ALFKI" CompanyName="Alfreds Futterkiste"
    ContactName="Maria Anders" ContactTitle="Sales Representative"
    Address="Obere Str. 57" City="Berlin" Region="" PostalCode="12209"
    Country="UK" Phone="030-0074321" Fax="030-0076545"/>
  <row CustomerID="ANATR" CompanyName="Ana Trujillo
    Emparedados y helados" ContactName="Ana Trujillo"
    ContactTitle="Owner" Address="Avda. de la Constitución 2222"
    City="México D.F." Region="" PostalCode="05021" Country="Mexico"
    Phone="(5) 555-4729" Fax="(5) 555-3745"/>
  <row CustomerID="ANTON" CompanyName="Antonio Moreno
    Taquería" ContactName="Antonio Moreno" ContactTitle="Owner"
    Address="Mataderos 2312" City="México D.F." Region=""
    PostalCode="05023" Country="Mexico" Phone="(5) 555-3932"
    Fax=""/>

```

Figure 3-10. Columns exported as attributes

The root element is `<table>` again, which will contain one or more `<row>` elements. Each `<row>` element will have one or more attributes representing the column values. The attribute name will be the same as the column name.

All XML documents need to have the XML processing instruction at the top. To include this processing instruction, we call the `WriteStartDocument()` method. Then the code writes a comment specifying the date and time at which the file is exported. The `WriteComment()` method accepts the comment string and writes it into the document. The root element `<table>` is then written to the document by using the `WriteStartElement()` method, which accepts the name of the element to be written and writes it to the file. Note that you need not specify the `<` and `>` characters while specifying the element name. Thus, when you pass `table` as the parameter to the `WriteStartElement()` method, it writes `<table>` into the file.

The code now starts iterating through the available records. The `Read()` method of the `SqlDataReader` class advances the record pointer to the next row and reads values from that row. It returns true if the record can be read successfully; otherwise, it returns false.

Exporting Columns As Elements

If the columns are to be exported as elements (that is, the first radio button is selected), the `<row>` element will not have any attributes. A for loop iterates through all the columns of the current row. The `FieldCount` property of the `SqlDataReader` class returns the total number of columns in the result set. With each iteration of the for loop, a new element is created by using the `WriteStartElement()` method. This time the `WriteStartElement()` method accepts the column name returned by the `GetName()` method of the `SqlDataReader` class, which accepts the column index and returns the column name.

To write the actual value of the column, the `WriteString()` method is called. This method accepts the string to be written, which in our example is retrieved by using the `GetValue()` method of `SqlDataReader`. The `GetValue()` method accepts a column index and returns the contents as an object. The code then calls the `ToString()` method on the returned object to get its string representation.

After the element value is written, the code calls the `WriteEndElement()` method of `XmlTextWriter` to write the innermost end element to the file. The `WriteEndElement()` method correctly writes the end element depending on the nesting of the document.

When you run the application and export your table, your output should resemble Figure 3-9.

Exporting Columns As Attributes

If the column values are to be written as attributes instead of elements, a similar process is followed. This time, however, the code uses the `WriteAttributeString()` method of `XmlTextWriter` to write the attributes. The `WriteAttributeString()` method accepts two parameters: the name of the attribute and the value of the attribute.

After writing all the end elements, the code closes the `XmlTextWriter` by calling its `Close()` method. Similarly, `SqlDataReader` and `SqlConnection` are also closed.

When you run the application and export your table, your output should resemble Figure 3-10.

Specifying Character Encoding

In the previous example, we constructed the `XmlTextWriter` class by providing a filename and the character encoding. In this case, the encoding parameter was null, but there are a few more encoding options in the .NET Framework. They are available as properties of the `Encoding` class, which resides in the `System.Text` namespace. Some of the common encodings are shown in Table 3-1.

Table 3-1. Properties of the `Encoding` Class

Property	Class Name	Description
<code>Encoding.ASCII</code>	<code>ASCIIEncoding</code>	Represents ASCII encoding. This encoding encodes Unicode characters as single 7-bit ASCII characters.
<code>Encoding.Unicode</code>	<code>UnicodeEncoding</code>	Represents Unicode encoding. This scheme encodes Unicode characters as 2 bytes (UTF-16).
<code>Encoding.UTF7</code>	<code>UTF7Encoding</code>	Represents UTF-7 encoding. The characters are stored in 7-bit format.
<code>Encoding.UTF8</code>	<code>UTF8Encoding</code>	Represents UTF-8 encoding. The characters are stored in 8-bit format. This is the default scheme.

Formatting the Output

If you open the XML document that we created in our previous example in Notepad, it will look like Figure 3-11.



```
<?xml version="1.0"?><!--File exported on 9/10/2008-->
<Customers>
  <Customer>
    <CustomerID>1</CustomerID>
    <CompanyName>Alfreds Futterkiste</CompanyName>
    <Address>Obere Str. 57</Address>
    <City>Berlin</City>
    <PostalCode>12209</PostalCode>
    <Country>Germany</Country>
    <Phone>(030) 12345678</Phone>
  </Customer>
  <Customer>
    <CustomerID>2</CustomerID>
    <CompanyName>Ana Trujillo Emparedados y helados</CompanyName>
    <Address>Avda. de la Constitución 222</Address>
    <City>Mérida</City>
    <PostalCode>99000</PostalCode>
    <Country>Mexico</Country>
    <Phone>(55) 555-3212</Phone>
  </Customer>
  <Customer>
    <CustomerID>3</CustomerID>
    <CompanyName>Antonio Moreno Taquería</CompanyName>
    <Address>Calle 43 128</Address>
    <City>Mérida</City>
    <PostalCode>99000</PostalCode>
    <Country>Mexico</Country>
    <Phone>(55) 555-9876</Phone>
  </Customer>
  <Customer>
    <CustomerID>4</CustomerID>
    <CompanyName>Centro comercial Moctezuma</CompanyName>
    <Address>Avda. 5 de Mayo #23</Address>
    <City>Mérida</City>
    <PostalCode>99000</PostalCode>
    <Country>Mexico</Country>
    <Phone>(55) 555-4241</Phone>
  </Customer>
  <Customer>
    <CustomerID>5</CustomerID>
    <CompanyName>Ernesto Gost  
ería y Repostería</CompanyName>
    <Address>Calle 43 128</Address>
    <City>Mérida</City>
    <PostalCode>99000</PostalCode>
    <Country>Mexico</Country>
    <Phone>(55) 555-9876</Phone>
  </Customer>
  <Customer>
    <CustomerID>6</CustomerID>
    <CompanyName>Lamia</CompanyName>
    <Address>Obra social 32</Address>
    <City>Mérida</City>
    <PostalCode>99000</PostalCode>
    <Country>Mexico</Country>
    <Phone>(55) 555-9876</Phone>
  </Customer>
  <Customer>
    <CustomerID>7</CustomerID>
    <CompanyName>Luisa Rascón Ltda.</CompanyName>
    <Address>Avda. 5 de Mayo #23</Address>
    <City>Mérida</City>
    <PostalCode>99000</PostalCode>
    <Country>Mexico</Country>
    <Phone>(55) 555-4241</Phone>
  </Customer>
  <Customer>
    <CustomerID>8</CustomerID>
    <CompanyName>País de la Cerveza</CompanyName>
    <Address>Calle 43 128</Address>
    <City>Mérida</City>
    <PostalCode>99000</PostalCode>
    <Country>Mexico</Country>
    <Phone>(55) 555-4241</Phone>
  </Customer>
  <Customer>
    <CustomerID>9</CustomerID>
    <CompanyName>Reyes del Mar S.A. de C.V.</CompanyName>
    <Address>Avda. 5 de Mayo #23</Address>
    <City>Mérida</City>
    <PostalCode>99000</PostalCode>
    <Country>Mexico</Country>
    <Phone>(55) 555-4241</Phone>
  </Customer>
  <Customer>
    <CustomerID>10</CustomerID>
    <CompanyName>Sierra Prado</CompanyName>
    <Address>Calle 43 128</Address>
    <City>Mérida</City>
    <PostalCode>99000</PostalCode>
    <Country>Mexico</Country>
    <Phone>(55) 555-4241</Phone>
  </Customer>
  <Customer>
    <CustomerID>11</CustomerID>
    <CompanyName>Supermercados El Sol</CompanyName>
    <Address>Avda. 5 de Mayo #23</Address>
    <City>Mérida</City>
    <PostalCode>99000</PostalCode>
    <Country>Mexico</Country>
    <Phone>(55) 555-4241</Phone>
  </Customer>
  <Customer>
    <CustomerID>12</CustomerID>
    <CompanyName>Trastienda La Leona</CompanyName>
    <Address>Calle 43 128</Address>
    <City>Mérida</City>
    <PostalCode>99000</PostalCode>
    <Country>Mexico</Country>
    <Phone>(55) 555-4241</Phone>
  </Customer>
  <Customer>
    <CustomerID>13</CustomerID>
    <CompanyName>Vista Alegre S.A. de C.V.</CompanyName>
    <Address>Avda. 5 de Mayo #23</Address>
    <City>Mérida</City>
    <PostalCode>99000</PostalCode>
    <Country>Mexico</Country>
    <Phone>(55) 555-4241</Phone>
  </Customer>
  <Customer>
    <CustomerID>14</CustomerID>
    <CompanyName>Wellington Importadora y Exportadora de Quesos</CompanyName>
    <Address>Calle 43 128</Address>
    <City>Mérida</City>
    <PostalCode>99000</PostalCode>
    <Country>Mexico</Country>
    <Phone>(55) 555-4241</Phone>
  </Customer>
  <Customer>
    <CustomerID>15</CustomerID>
    <CompanyName>Wistow Service Ltda.</CompanyName>
    <Address>Avda. 5 de Mayo #23</Address>
    <City>Mérida</City>
    <PostalCode>99000</PostalCode>
    <Country>Mexico</Country>
    <Phone>(55) 555-4241</Phone>
  </Customer>
  <Customer>
    <CustomerID>16</CustomerID>
    <CompanyName>Yankee Delicados S.A. de C.V.</CompanyName>
    <Address>Avda. 5 de Mayo #23</Address>
    <City>Mérida</City>
    <PostalCode>99000</PostalCode>
    <Country>Mexico</Country>
    <Phone>(55) 555-4241</Phone>
  </Customer>
  <Customer>
    <CustomerID>17</CustomerID>
    <CompanyName>Zarzuela S.A. de C.V.</CompanyName>
    <Address>Avda. 5 de Mayo #23</Address>
    <City>Mérida</City>
    <PostalCode>99000</PostalCode>
    <Country>Mexico</Country>
    <Phone>(55) 555-4241</Phone>
  </Customer>
</Customers>
```

Figure 3-11. XML document without any formatting

What's the problem? Well, there is no problem as far as the document being well formed. It does follow all the rules of XML grammar. However, the document lacks proper formatting. Such documents are difficult for the human eye to read. Fortunately, the `XmlTextWriter` class provides several formatting options that help you create well-formatted documents.

To see how these formatting options work, you need to modify the previous application so it looks like the one shown in Figure 3-12.

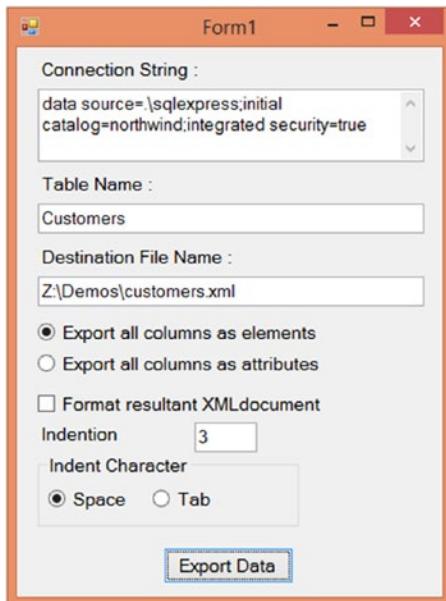


Figure 3-12. Formatting the XML document

The application has a check box that toggles whether the document will be formatted. You can specify the indentation as well as the indent character (space or tab).

The code in the Click event handler of the Export Data button needs to be modified as shown in Listing 3-7.

Listing 3-7. Formatting XML Document While Writing

```
private void button1_Click(object sender, EventArgs e)
{
    SqlConnection cnn = new SqlConnection(textBox1.Text);
    SqlCommand cmd = new SqlCommand();
    cmd.Connection = cnn;
    cmd.CommandText = $"SELECT * FROM {textBox2.Text}";
    cnn.Open();
    SqlDataReader reader = cmd.ExecuteReader();
    XmlTextWriter writer = new XmlTextWriter(textBox3.Text, null);

    if(checkBox1.Checked)
    {
        writer.Formatting = Formatting.Indented;
        writer.Indentation = int.Parse(textBox4.Text);
        writer.IndentChar = (radioButton3.Checked ? ' ' : '\t');
    }

    writer.WriteStartDocument();
    writer.WriteComment($"File exported on {DateTime.Now}");
    writer.WriteStartElement("table");

    while (reader.Read())
    {
        if (radioButton1.Checked)
        {
            writer.WriteStartElement("row");
            for (int i = 0; i < reader.FieldCount; i++)
            {
                writer.WriteStartElement(reader.GetName(i));
                writer.WriteString(reader.GetValue(i).ToString());
                writer.WriteEndElement();
            }
            writer.WriteEndElement();
        }
        else
        {
            writer.WriteStartElement("row");
            for (int i = 0; i < reader.FieldCount; i++)
            {
                writer.WriteAttributeString(reader.GetName(i),
                    reader.GetValue(i).ToString());
            }
            writer.WriteEndElement();
        }
    }
}
```

```

writer.WriteLine();
writer.Close();
reader.Close();
cnn.Close();
}
}

```

Note the code marked in bold. The `Formatting` property of `XmlTextWriter` governs whether the document will be formatted. The `Formatting` property is an enumeration of type `Formatting` and contains two possible values: `None` and `Indented`. The `Indentation` property of `XmlTextWriter` specifies the number of indent characters to be written in the document. This property is useful only if `Formatting` is set to `Indented`. The `IndentChar` property holds the character to be used for indentation. Though you can specify any valid character for `IndentChar`, space and tab are commonly used.

If you export the `Customers` table after making the preceding modifications, the resultant document should resemble Figure 3-13.

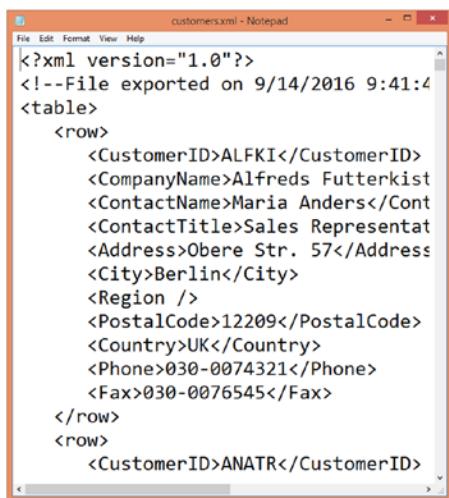


Figure 3-13. Well-formatted XML document

Much better than the previous one, isn't it?

Though not covered by our application, you can also set the `QuoteChar` property to decide which character to use for enclosing attribute values. The default value for `QuoteChar` is the double-quote character.

Including Namespace Support

Recall from Chapter 2 and the earlier discussion in this chapter that XML namespaces provide a method for uniquely qualifying element and attribute names used in an XML document by associating them with a namespace. When you create XML documents by using `XmlTextWriter`, you may need to include namespace support for the resultant document. That is what you are going to see in this section.

Various methods of `XmlTextWriter`, such as `WriteStartElement()`, provide overloads that can be used to specify namespace and prefix information. To see how these overloads can be used, you need to modify the previous application so it looks like the one shown in Figure 3-14.

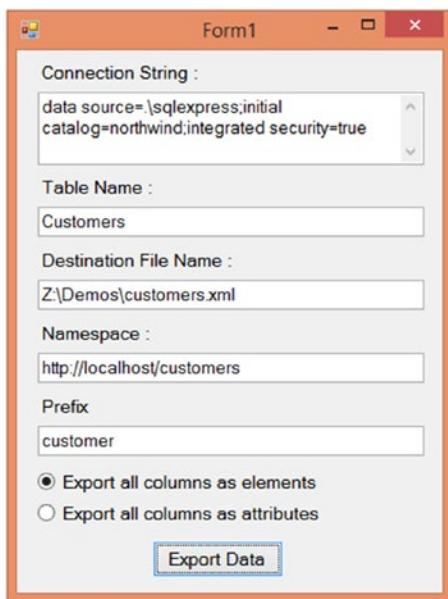


Figure 3-14. Namespace support in XmlTextWriter

As you can see in Figure 3-14, there are text boxes for accepting the namespace URI and prefix from the user. The modified code that adds namespace support is shown in Listing 3-8.

Listing 3-8. Namespace Support in XmlTextWriter

```
private void button1_Click(object sender, EventArgs e)
{
    SqlConnection cnn = new SqlConnection(textBox1.Text);
    SqlCommand cmd = new SqlCommand();
    cmd.Connection = cnn;
    cmd.CommandText = $"SELECT * FROM {textBox2.Text}";
    cnn.Open();
    SqlDataReader reader = cmd.ExecuteReader();
    XmlTextWriter writer = new XmlTextWriter(textBox3.Text, null);
    writer.WriteStartDocument();
    writer.WriteComment($"File exported on {DateTime.Now}");
writer.WriteStartElement(textBox5.Text, "table", textBox4.Text);

    while (reader.Read())
    {
        if (radioButton1.Checked)
        {
            writer.WriteStartElement(textBox5.Text, "row", textBox4.Text);
            for (int i = 0; i < reader.FieldCount; i++)
            {
                writer.WriteStartElement(textBox5.Text, reader.GetName(i),
                    textBox4.Text);
                writer.WriteString(reader.GetValue(i).ToString());
            }
        }
    }
}
```

```

        writer.WriteEndElement();
    }
    writer.WriteEndElement();
}
else
{
    writer.WriteStartElement(textBox5.Text, "row", textBox4.Text);
    for (int i = 0; i < reader.FieldCount; i++)
    {
        writer.WriteString(textBox5.Text, reader.GetName(i),
                           textBox4.Text,
                           reader.GetValue(i).ToString());
    }
    writer.WriteEndElement();
}
writer.WriteEndElement();
writer.Close();
reader.Close();
cnn.Close();
}
}

```

Notice the lines marked in bold. The `WriteStartElement()` and `WriteAttributeString()` methods have an overload that accepts a prefix and namespace URI. If you create XML documents by using these overloads, your document should resemble Figure 3-15.

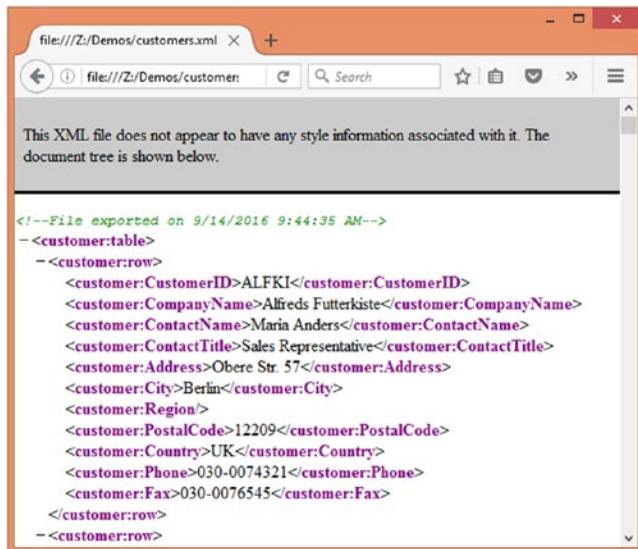


Figure 3-15. XML document with namespaces and prefix added

Notice how the namespace has been added to the `<table>` element:

```
<customer:table xmlns:customer="http://localhost/customers">
```

Also notice how each element now bears the prefix.

Dealing with Nontextual Data

Up until now, we have been using `XmlReader` and `XmlWriter` to read textual data. However, at times you may need to deal with nontextual data as well. For example, you may want to serialize image files or binary files as XML data in order to pass it over the Internet in a firewall-friendly way. Thankfully, both `XmlTextReader` and `XmlTextWriter` provide ways to handle such situations.

To help you understand how `XmlTextReader` and `XmlTextWriter` can be used to work with nontextual data, we will develop an application like the one shown in Figure 3-16.

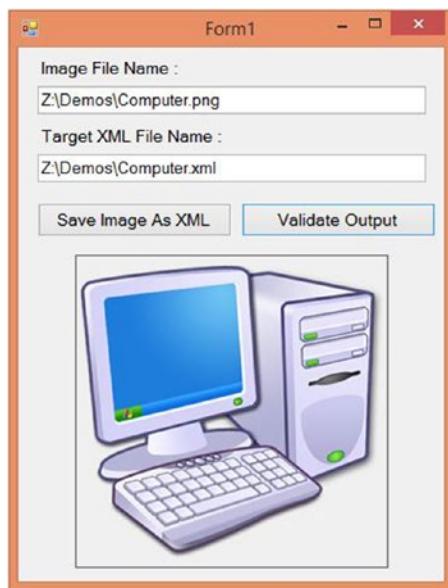


Figure 3-16. Dealing with nontextual data

The application allows you to read any image file and serialize it as an XML document. You can specify the source image filename and the destination XML filename in the text boxes. After you save the image as an XML document, you can validate whether the serialized image is correct by loading it in a picture box.

Serializing Data

Listing 3-9 shows the Click event handler of the Save Image as XML button.

Listing 3-9. Writing Base64 Data

```
private void button1_Click(object sender, EventArgs e)
{
    XmlTextWriter writer = new XmlTextWriter(textBox2.Text, null);
    FileStream fs = File.OpenRead(textBox1.Text);
    byte[] data = new byte[fs.Length];
    fs.Position = 0;
    fs.Read(data, 0, data.Length);
    fs.Close();
    writer.WriteStartDocument();
    writer.WriteStartElement("imagefile");
    writer.WriteAttributeString("filename", textBox1.Text);
    writer.WriteAttributeString("size", data.Length.ToString());
    writer.WriteBase64(data,0,data.Length);
    writer.WriteEndElement();
    writer.Close();
}
```

The code creates an `XmlTextWriter` object by passing the path of the destination XML file to the constructor. Then a `FileStream` is created for reading data from the image file. The contents of the file are read by using the `Read()` method of the `FileStream` class, which accepts three parameters: the byte array to read the data into, the start index in the byte array from where the writing should start, and the length of data to read. The `XmlTextWriter` then starts writing the document. It first writes the XML processing instruction and the `<imagefile>` element. The `<imagefile>` element has two attributes: `filename` and `size`. The `filename` attribute stores the complete path of the image file that is being serialized as XML. The `size` attribute contains the size of the source image file.

Image files contain nontextual data. You have a couple of options when you want to serialize nontextual data into XML files. You can use either hexadecimal encoding or Base64 encoding for the serialization. In our example, we use Base64 encoding. To write data into Base64 format, the `XmlTextWriter` class provides a method called `WriteBase64()`, which accepts three parameters: a byte array that contains the nontextual data, the index of the byte array from which the writing should start, and the length of data to write. The `WriteBase64()` method writes the supplied byte array as a Base64 string inside the destination XML element. Figure 3-17 shows how the XML file looks after serializing an image file.

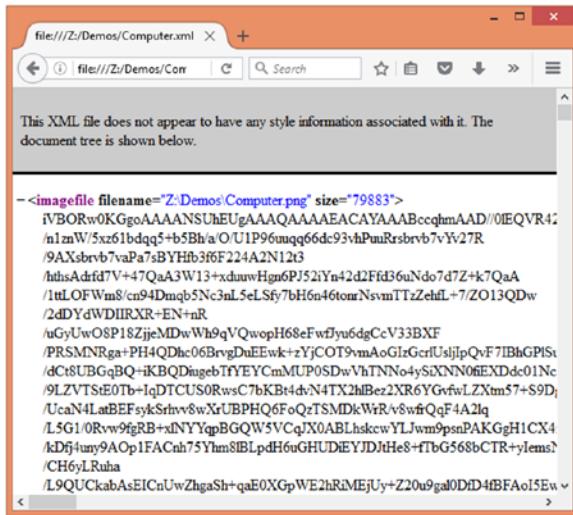


Figure 3-17. Image file serialized in Base64 format

Now that you know how to write nontextual data by using `XmlTextWriter`, you're ready to see how to use `XmlTextReader` to read the document back.

Deserializing Data

The Click event handler of the Validate Document button contains the code shown in Listing 3-10.

Listing 3-10. Reading Base64 Data

```

private void button2_Click(object sender, EventArgs e)
{
    XmlTextReader reader = new XmlTextReader(textBox2.Text);
    reader.WhiteSpaceHandling = WhiteSpaceHandling.None;

    while (reader.Read())
    {
        if (reader.NodeType == XmlNodeType.Element)
        {
            if (reader.Name == "imagefile")
            {
                int length = int.Parse(reader.GetAttribute("size"));
                string filename = reader.GetAttribute("filename");
                byte[] imagedata = new byte[length];
                int i = reader.ReadElementContentAsBase64(imagedata, 0, length);
                MemoryStream ms = new MemoryStream();
                ms.Write(imagedata, 0, imagedata.Length);
                Image image = Image.FromStream(ms);
            }
        }
    }
}

```

```
    pictureBox1.Image = image;
    ms.Close();
}
}
}
```

The code creates an instance of the `XmlTextReader` class by passing the XML document we just created. It then starts reading the document. If the element name is `imagefile`, the code reads the two attributes `filename` and `size`. Based on the value of the `size` attribute, a byte array is created with that much capacity. The contents of the `<imagefile>` element are read by using the `ReadElementContentAsBase64()` method.

The `ReadElementContentAsBase64()` method converts the Base64 encoded string into a byte array. The method returns an integer indicating the number of bytes written to the array. The byte array filled by the `ReadElementContentAsBase64()` is written to a `MemoryStream` object; the `MemoryStream` is then converted into an `Image` object. This is accomplished by using the `FromStream()` static method of the `Image` class, which returns an instance of the `Image` class constructed from the supplied stream. Finally, the `Image` instance is assigned to the `Image` property of the picture box control.

Summary

This chapter covered two important classes: `XmlTextReader` and `XmlTextWriter`. They are implementations of the abstract base classes `XmlReader` and `XmlWriter`, respectively. The `XmlTextReader` class represents a read-only parser that can parse XML documents very quickly. Because it does not load the entire XML document in memory, its memory footprint is small. It provides a cursor-oriented model to read the XML documents. The `XmlTextWriter` class allows you to quickly create XML documents and serialize nontextual data in Base64 or hexadecimal format.

You can also create your own custom readers and writers by inheriting from the `XmlReader` and `XmlWriter` abstract classes.

CHAPTER 4



Accessing XML Documents Using the XPath Data Model

In Chapters 2 and 3, you learned how to read and write XML documents by using the `XmlDocument`, `XmlReader`, and `XmlWriter` classes. These classes allow you to access the underlying documents, but by themselves they hardly provide a way to query and retrieve the data. That is why we need something that allows us to navigate, query, and retrieve data from XML documents easily and efficiently. The XPath standard is designed to do just that.

The .NET Framework namespace `System.Xml.XPath` provides a complete set of classes that allow you to query and retrieve data from an XML document by using the XPath data model. Recollect that in Chapter 2 we used the `SelectNodes()` and `SelectSingleNode()` methods that use XPath expressions. In this chapter, I discuss XPath at length. Specifically, you will learn about the following:

- The location path, axis, and node tests
- The XPath built-in functions
- How to use the `XPathNavigator` class along with XPath
- How to read and write XML data by using the `XPathNavigator` class

Overview of XPath

XPath provides a way to query and select a part of an XML document. To work with XPath expressions, you must understand some of the basic terminology. Specifically, you must be comfortable with the following terms:

- Location path
- Axis
- Node tests
- Predicates

Location Path

We are all familiar with the Windows file system. In the file system, each file has a path and we denote that path by using a specific notation. Similarly, various parts of an XML document, such as elements and attributes, also have a location. The location is indicated by a specific XPath syntax called the *location path*, which allows you to select a set of nodes from an XML document. A location path consists of an axis, a node test, and predicates.

Axis

When dealing with file system paths, we normally start with the drive letter. Thus the drive letter forms the basis for locating the file. A similar role is played by the axis for XML documents. The *axis* partitions the XML document based on the current node, so by using an axis you specify the starting point to apply node tests and predicates. The available axes are listed in Table 4-1.

Table 4-1. XPath Axes

Axis	Description
Self	Represents the current node (often the context node)
Child	Represents the children of the context node
Parent	Represents the parent of the context node
Attribute	Represents attributes of the context node
Descendant	Represents all the child nodes of the context node
Ancestor	Represents parent, grandparent, and so on until the document root
Following	Represents all the nodes that come after the context node
Following-sibling	Represents the sibling nodes following the context node
Preceding	Represents all the nodes that come before the context node
Preceding-sibling	Represents the preceding sibling of the context node

Node Tests

Node tests allow you to test elements and node types for a certain condition and return the selected elements or nodes. You can use the asterisk (*) character to indicate all the nodes. Some of the commonly used node tests are as follows:

- Testing elements with the same name as the supplied element name
- Testing all the nodes of a specific axis
- Testing all the text elements of a specific axis
- Testing all the comments of a specific axis
- Testing all the processing instructions of a specific axis

Predicates

Predicates are Boolean expressions that are used to further filter the nodes selected by the axis and node test. The XPath specifications provide a good number of functions that you can use to form predicates. The return values of these functions can be compared or checked with the help of familiar operators, such as =, !=, <, >, <=, >=, and so on.

Putting It All Together

Now that you know the meaning of the XPath terms, let's see what a location path looks like. The general syntax of a location path is given here:

`Axis::node-test[predicate]`

The axis is separated from the rest of the path by the `::` operator. The node test typically contains a series of nodes, that is, a path. Finally, the predicate is specified in a set of square brackets. Here is an example of a location path:

`following::employee[@employeeid='2']`

The preceding location path points to the employee node following the current node whose `employeeid` attribute is 2.

Here are the XPath expressions that we used in Chapter 2:

```
//employee[./firstname/text()='some_text']
//employee[@employeeid='1']
```

In both cases, the axis is the root node as indicated by `//`. The node test consists of a single node (`employee`). The predicate for the first expression tests whether the text value of the `firstname` node of the current employee node matches some specific text. The predicate for the second expression checks whether the `employeeid` attribute (the attribute axis can be abbreviated as `@`) of the current employee node is 1.

XPath Functions

The XPath specification provides several built-in functions. These functions can be grouped in the following way:

- Functions that work on a set of nodes
- Functions that return a Boolean value
- Functions that work on strings
- Functions that work on numbers

These functions are listed in Tables 4-2 through 4-5.

Table 4-2. Functions That Work on a Set of Nodes

Function Name	Description
last()	Returns the number of nodes in the current node set
position()	Returns the index of the context node in the current node set
count()	Returns the total number of nodes in the given node set
id()	Returns a node set containing nodes with an ID attribute matching the specified value
name()	Returns the fully qualified name of the specified node
text()	Returns the text of the specified node
local-name()	Returns the local name of the node
namespace-uri()	Returns the namespace of the node

Table 4-3. Functions That Return Boolean Values

Function Name	Description
not()	Returns true if the supplied value is false; otherwise, returns false
true()	Returns true
false()	Returns false

Table 4-4. Functions That Work on Strings

Function Name	Description
concat()	Returns a concatenated string
starts-with()	Returns true if the string starts with the specified letters
contains()	Returns true if the string contains the specified string
substring()	Returns part of the specified string
string-length()	Returns the number of characters in the string
translate()	Replaces characters from a string with the specified characters

Table 4-5. Functions That Work on Numbers

Function Name	Description
number()	Converts the specified string to its equivalent number
sum()	Returns the sum of numbers
floor()	Returns a number rounded down to the next integer
ceiling()	Returns a number rounded up to the next integer
round()	Returns a number rounded to the nearest integer

Now that you have a good understanding of XPath, location paths, and XPath functions, let's delve further into the .NET Framework's XPath data model.

The XPath Data Model

The XPath data model of the .NET Framework relies on a class called `XPathNavigator` residing in the `System.Xml.XPath` namespace. The `XPathNavigator` class is an abstract class and provides a cursor-based navigation model for the underlying XML data. It also allows you to edit XML documents. You can obtain an `XPathNavigator` instance from any class that implements the `IXPathNavigable` interface. The classes that already implement this interface are `XmlDocument` and `XPathDocument`.

You have already worked with the `XmlDocument` class and hence it needs no explanation. The `XPathDocument` class, which resides in the `System.Xml.XPath` namespace, provides a read-only representation of an XML document using the XPath data model. It loads the document in memory and naturally provides fast access to various parts of the document.

The `XPathNavigator` instance returned from `XmlDocument` is editable, whereas that returned by `XPathDocument` is read-only.

Creating `XPathNavigator`

You can obtain an instance of `XPathNavigator` from either `XmlDocument` or `XPathDocument`. Both of these classes implement the `IXPathNavigable` interface and provide a method called `CreateNavigator()` that creates and returns an object of type `XPathNavigator`.

To see how these classes can be used, you need to develop a Windows Forms application like the one shown in Figure 4-1.

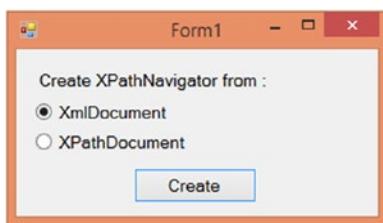


Figure 4-1. Creating `XPathNavigator`

The application consists of two radio buttons that allow you to select whether to use `XmlDocument` or `XPathDocument` to create your `XPathNavigator`. When you click the Create button, the `XPathNavigator` instance is created depending on the selected radio button. Note that you need to import the `System.Xml` and `System.Xml.XPath` namespaces before you write any code. Listing 4-1 shows the code from the Click event handler of the Create button.

Listing 4-1. Creating `XPathNavigator`

```
private void button1_Click(object sender, EventArgs e)
{
    XPathNavigator navigator = null;
    if (radioButton1.Checked)
    {
        XmlDocument doc = new XmlDocument();
```

```

doc.Load($"{Application.StartupPath}\\employees.xml");
navigator = doc.CreateNavigator();
}
else
{
    XPathDocument doc =
        new XPathDocument($"{Application.StartupPath}\\employees.xml");
    navigator = doc.CreateNavigator();
}
MessageBox.Show("Navigator created successfully!");
}

```

The code begins by declaring a variable of type `XPathNavigator` at the top of the event handler. It then checks which radio button is selected. If the `XPathNavigator` is to be created from `XmlDocument`, it creates an instance of the `XmlDocument` class. It then loads the `Employees.xml` file with the help of the `Load()` method of `XmlDocument`. The `CreateNavigator()` method of `XmlDocument` is then called to create and return an instance of the `XPathNavigator` class.

If the navigator is to be created from `XPathDocument`, the code creates an instance of the `XPathDocument` class. There are several overloads on the constructor of this class; our code uses the one that accepts the path to the XML file. The `CreateNavigator()` method of `XPathDocument` creates and returns an instance of `XPathNavigator`. Finally, a message box is displayed just to report the success of the operation.

Navigating an XML Document Using `XPathNavigator`

In the previous section, you learned to create `XPathNavigator` from `XmlDocument` and `XPathDocument`. In this section, you will see how to use `XPathNavigator` and access various elements and attributes.

To work through this section, you need to create a Windows Forms application like the one shown in Figure 4-2.

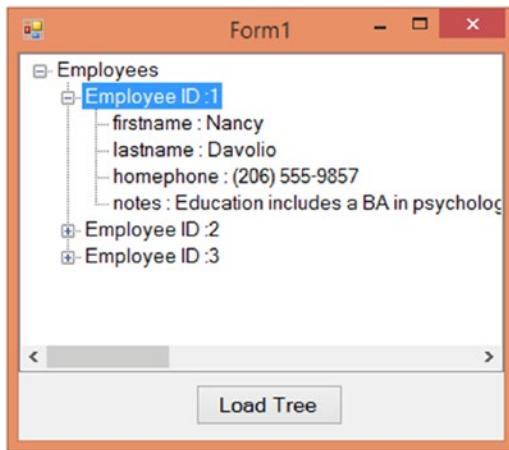


Figure 4-2. Navigating through `XPathNavigator`

The application consists of a `TreeView` and a button. After you click the `Load Tree` button, the `TreeView` is populated with employee information from the `Employees.xml` file. The `Click` event handler of the `Load Tree` button contains the code shown in Listing 4-2.

Listing 4-2. Navigating by Using XPathNavigator

```

private void button1_Click(object sender, EventArgs e)
{
    XPathDocument doc =
        new XPathDocument("${Application.StartupPath}\\employees.xml");
    XPathNavigator navigator = doc.CreateNavigator();
    navigator.MoveToRoot();
    navigator.MoveToFirstChild();

    TreeNode root = treeView1.Nodes.Add("Employees");

    while (navigator.MoveNext())
    {
        if (navigator.HasChildren)
        {
            navigator.MoveToFirstChild();
            do
            {
                string id = navigator.GetAttribute("employeeid", "");
                TreeNode emppnode = new TreeNode($"Employee ID :{id}");
                root.Nodes.Add(emppnode);
                navigator.MoveToFirstChild();

                do
                {
                    string name = navigator.Name;
                    TreeNode node = new TreeNode($"{name} : {navigator.Value}");
                    emppnode.Nodes.Add(node);
                } while (navigator.MoveNext());

                navigator.MoveToParent();
            } while (navigator.MoveNext());
        }
    }
}

```

The code begins by creating an instance of the `XPathDocument` class by passing the path of the XML file to its constructor. It then creates an `XPathNavigator` by calling the `CreateNavigator()` method of the `XPathDocument` class. We need to iterate through the document from the root and hence we call the `MoveToRoot()` method of `XPathNavigator`. This method moves the cursor of the `XPathNavigator` to the root of the document. Note that here the root of the document is the node that contains the entire tree of nodes. Because we want to start the iteration from the `<employees>` node, we call the `MoveToFirstChild()` method. Calling this method will place the navigator cursor at the `<employees>` node. A root node of the `TreeView` is then added.

Next there are three loops. The outermost loop iterates through all the child nodes of the root node. In our case, this loop will be executed just once, because there is only one `<employees>` node. The second loop iterates through all the `<employee>` nodes, whereas the innermost loop iterates through the child nodes of the `<employee>` node, that is, the `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>` nodes.

The outermost loop uses the `MoveToNext()` method of the `XPathNavigator` class to advance the cursor onto the next node. It then decides whether there are any `<employee>` nodes using the `HasChildren` property. The `HasChildren` property returns true if there are child nodes to the current node; otherwise, it returns false. If there are `<employee>` nodes, the cursor is moved to the first `<employee>` node by calling the `MoveToFirstChild()` method, which moves the navigator cursor to the first child node.

Now the code starts iterating through all the `<employee>` nodes. With each iteration, the value of the `employee` attribute is retrieved by using the `GetAttribute()` method. This method accepts two parameters: the name of the attribute to retrieve and the attribute namespace. Because our document does not contain any namespaces, an empty string is passed as the second parameter. A `TreeView` node is added for that employee ID. The cursor is then moved to the first child node of the `<employee>` node by using the `MoveToFirstChild()` method we discussed earlier. After this call, the cursor will be on the `<firstname>` node.

Now the innermost loop starts. With each iteration, the name of the node is retrieved by using the `Name` property, and the value of the node is retrieved by using the `Value` property. The same process is carried out for all the child nodes, that is, `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>`.

After the innermost loop is finished, the navigator cursor is moved back to the parent `<employee>` node. This is done with the help of the `MoveToParent()` method, which moves the cursor pointer to the parent node of the current node. The same process is repeated for the remaining `<employee>` nodes.

Selecting Nodes

This chapter began with a brief overview of XPath and its vocabulary, including terms such as *axis*, *node test*, *predicate*, and *function*. You might be wondering where they come into the picture. It's time now to see those features in action.

To test various XPath expressions, we will create a simple application that looks like the one shown in Figure 4-3.

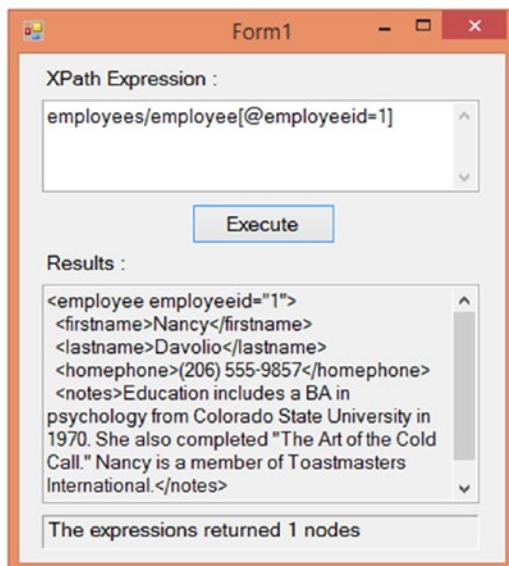


Figure 4-3. Executing XPath expressions

The application consists of a text box positioned at the top to enter XPath expressions. After you click the Execute button, the given expression is executed and its results are displayed in another text box at the bottom. The label at the bottom displays the total number of rows returned by the expression. Listing 4-3 shows the Click event handler of the Execute button.

Listing 4-3. Using the Select() Method

```
private void button1_Click(object sender, EventArgs e)
{
    XPathDocument doc =
        new XPathDocument("${Application.StartupPath}\\employees.xml");
    XPathNavigator navigator = doc.CreateNavigator();
    XPathNodeIterator iterator = navigator.Select(textBox1.Text);
    try
    {
        label3.Text = $"The expressions returned {iterator.Count} nodes";
        if (iterator.Count > 0)
        {
            while (iterator.MoveNext())
            {
                textBox2.Text = iterator.Current.OuterXml;
            }
        }
        else
        {
            textBox2.Text = "No results";
        }
    }
    catch (Exception ex)
    {
        MessageBox.Show(ex.Message);
    }
}
```

The code creates an instance of `XPathDocument` by passing the path of the `Employees.xml` file. Then an `XPathNavigator` is obtained by using the `CreateNavigator()` method of `XPathDocument`. The code then calls the `Select()` method of `XPathNavigator`, which accepts an XPath expression and returns an instance of `XPathNodeIterator`.

The `XPathNodeIterator` class allows you to iterate through the returned nodes and has a number of properties and methods to assist you. To start with, the `Count` property tells you how many nodes were selected by the `Select()` method. After you are satisfied that there were some results, you can iterate through the selected nodes by using the `MoveNext()` method. On each node, you then use the `Current` property to get a reference to the `XPathNavigator` positioned at the current node. You can then call any of the methods and properties of `XPathNavigator`.

In our example, we simply display the `OuterXml` property of the underlying `XPathNavigator` in a text box. Though not used in our example, the `CurrentPosition` property of `XPathNodeIterator` returns the current index of the node being accessed.

Now let's try some XPath expressions by using our application. Some XPath expressions relevant to our XML document (`Employees.xml`) are given in Table 4-6.

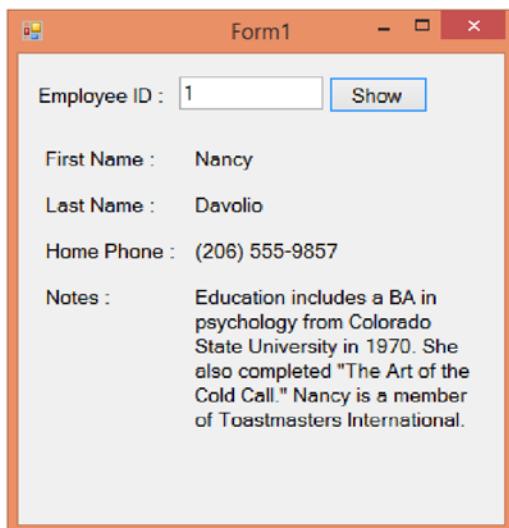
Table 4-6. Examples of XPath Expressions

Purpose	Expression
To select an employee whose employee ID is 1	employees/employee[@employeeid=1]
To select the employee whose first name is Andrew	employees/employee[firstname/text()='Andrew']
To select the last employee from the document	employees/employee[last()]
To select the employee whose index is 2	employees/employee[position()=2]
To select an employee whose name contains <i>Nancy</i>	employees/employee[contains(firstname, 'Nancy')]
To select the name of the first employee	employees/employee/firstname[text()]

Selecting Single Nodes

The `Select()` method returns all the nodes that are obtained after evaluating the XPath expression. There is a method called `SelectSingleNode()` that executes the supplied XPath expression and returns an `XPathNavigator` object (and not an `XPathNodeIterator`) that contains the first matching node for the specified expression. You can then use the `XPathNavigator` object to navigate through the nodes. `SelectSingleNode()` comes in handy when you know that your XPath expression is going to return just one node. For example, in our document we can use `SelectSingleNode()` to extract an employee matching a specific employee ID.

To illustrate the use of `SelectSingleNode()`, you need to develop an application like the one shown in Figure 4-4.

**Figure 4-4.** Using the `SelectSingleNode()` method

The application contains a text box to accept an employee ID and nine labels. Clicking the Show button displays details of an employee, and because the employee ID is unique in `Employees.xml`, we can safely use `SelectSingleNode()` here. Listing 4-4 shows the relevant code.

Listing 4-4. Calling the `SelectSingleNode()` Method

```
private void button1_Click(object sender, EventArgs e)
{
    XPathDocument doc =
        new XPathDocument("${Application.StartupPath}\\employees.xml");
    XPathNavigator navigator = doc.CreateNavigator();
    XPathNavigator result =
        navigator.SelectSingleNode($"employees/employee
            [@employeeid={textBox1.Text}]");
    result.MoveToFirstChild();
    do
    {
        switch (result.Name)
        {
            case "firstname":
                label6.Text=result.Value;
                break;
            case "lastname":
                label7.Text=result.Value;
                break;
            case "homephone":
                label8.Text=result.Value;
                break;
            case "notes":
                label9.Text=result.Value;
                break;
        }
    }
    while (result.MoveNext());
}
```

The code obtains an `XPathNavigator` object from an `XPathDocument` class. To retrieve the `<employee>` node with the specified employee ID, we use `SelectSingleNode()`, by supplying the appropriate XPath expression. It in turn returns `XPathNavigator` object containing the returned node.

The code then iterates through all the child nodes (`<firstname>`, `<lastname>`, `<homephone>`, and `<notes>`) of the returned `<employee>` node. With each iteration, the corresponding values are extracted by using the `Value` property of `XPathNavigator`.

Selecting Children, Ancestors, and Descendants

In addition to `Select()` and `SelectSingleNode()`, you can also use three specialized methods:

- The `SelectChildren()` method accepts the name of the child node and returns an `XPathNodeIterator` containing all the child nodes of the current node matching the supplied name.
- The `SelectAncestors()` method accepts the name of the ancestor nodes to select and returns an `XPathNodeIterator` containing all the ancestor nodes of the current node.

- The `SelectDescendants()` method accepts a node name and returns an `XPathNodeIterator` containing all the descendant nodes of the current node matching the supplied name.

These methods are optimized for performance and hence are faster than the equivalent XPath expressions.

Compiling XPath Expressions

If you are using the same XPath expression again and again, you can improve the performance of your code by using the `Compile()` method of the `XPathNavigator` class. This method accepts an XPath expression as a string, compiles it, and returns an instance of the `XPathExpression` class. This instance can then be supplied to the `Select()` and `SelectSingleNode()` methods.

To see the `Compile()` method in action, you need to modify the example that we developed for selecting nodes (see the “Selecting Nodes” section). The modified code is given in Listing 4-5.

Listing 4-5. Using `XPathExpression` and the `Compile()` Method

```
private void button1_Click(object sender, EventArgs e)
{
    XPathDocument doc =
        new XPathDocument("${Application.StartupPath}\\\employees.xml");
    XPathNavigator navigator = doc.CreateNavigator();
XPathExpression expression = navigator.Compile(textBox1.Text);
XPathNodeIterator iterator = navigator.Select(expression);
    try
    {
        ...
    }
```

Note the lines marked in bold. The code creates an instance of the `XPathExpression` class by calling the `Compile()` method of `XPathNavigator`. This `XPathExpression` instance is then passed to the `Select()` method. The rest of the code of the application remains unchanged. You can pass the same `XPathExpression` instance to any number of `Select()` or `SelectSingleNode()` calls.

Navigating Between Attributes

Previously we accessed the attribute value by using the `GetAttribute()` method of the `XPathNavigator` class. However, there is an alternate technique that allows you to move through the available attributes by using three methods of `XPathNavigator`: `MoveToAttribute()`, `MoveToFirstAttribute()`, and `MoveToNextAttribute()`. These methods allow you to move to a specific attribute, the first attribute, and the next attribute, respectively.

The previous example can be modified as shown in Listing 4-6.

Listing 4-6. Accessing Attributes by Using the `MoveTo . . .` Methods

```
navigator.MoveToAttribute("employeeid", "");
string id = navigator.Value;
navigator.MoveToParent();
```

As you can see, the code now calls the `MoveToAttribute()` method instead of `GetAttribute()`. The `MoveToAttribute()` method takes the same two parameters as `GetAttribute()`, that is, the name of the attribute and the attribute namespace. To access the attribute's value this time, we use the `Value` property of `XPathNavigator`. Because the cursor has been moved to the `employeeid` attribute, the `Value` property returns its value. Before continuing, the cursor is positioned back to the `<employee>` node by calling the `MoveToParent()` method.

Retrieving Inner and Outer XML

In the previous sections, we used the `Value` property of `XPathNavigator` to access the text of various attributes and nodes. There are two more properties—`InnerText` and `OuterXml`—that return the contents of the `XPathNavigator` as a string. The `InnerText` property returns the complete markup of all the child nodes (excluding any markup of the current node), whereas the `OuterXml` property returns the complete markup of the node and all the child nodes.

To see how these properties are used, you need to develop an application like the one shown in Figure 4-5.

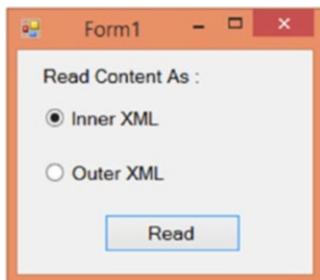


Figure 4-5. Inner and outer XML

The application contains two radio buttons to indicate inner or outer XML options. The Read button reads the `Employees.xml` file and displays the content as per the selection made. Listing 4-7 shows the Click event handler of the Read button containing the relevant code.

Listing 4-7. Using `InnerText` and `OuterXml` Properties

```
private void button1_Click(object sender, EventArgs e)
{
    XPathDocument doc=new XPathDocument("${Application.StartupPath}\\employees.xml");
    XPathNavigator navigator = doc.CreateNavigator();
    navigator.MoveToRoot();
    navigator.MoveToFirstChild();

    while (navigator.MoveNext())
    {
        if (radioButton1.Checked)
        {
            MessageBox.Show(navigator.InnerText);
        }
    }
}
```

```
else
{
    MessageBox.Show(navigator.OuterXml);
}
}
```

The code creates an instance of `XPathDocument` as before. The `XPathNavigator` is then obtained by using the `CreateNavigator()` method of the `XPathDocument` class. As you learned in the previous examples, the cursor is positioned at the `<employees>` node. Finally, the entire content of the `<employees>` node is retrieved by using the `InnerXml` and `OuterXml` properties of the `XPathNavigator` class. The resultant message boxes for `InnerXml` and `OuterXml` are shown in Figures 4-6 and 4-7.

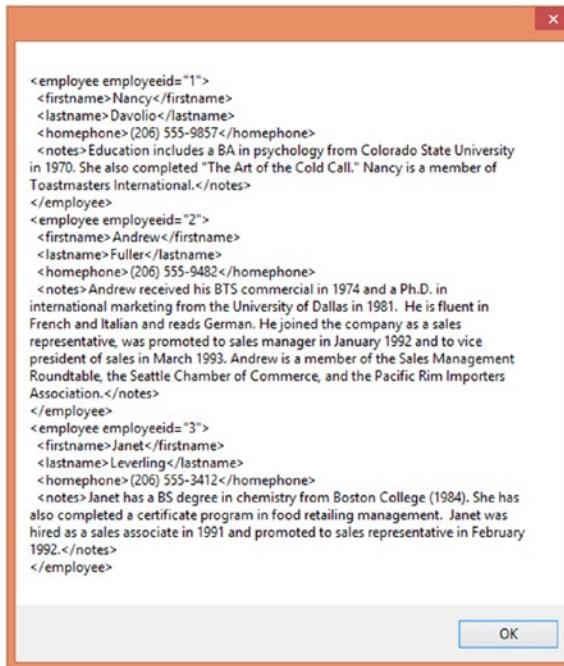


Figure 4-6. Output of the `InnerXml` property



Figure 4-7. Output of the OuterXml property

Note how OuterXml returns markup of the <employees> node, whereas InnerXml doesn't.

Getting an XmlReader from XPathNavigator

Though XPathNavigator allows you to read the XML document, at times you may want to pass a set of nodes from XPathNavigator to an XmlReader. The XmlReader can then read the returned nodes further. This is accomplished by using the ReadSubTree() method of XPathNavigator.

To demonstrate how an XmlReader can be obtained from an XPathNavigator, you need to build a Windows Forms application like the one shown in Figure 4-8.

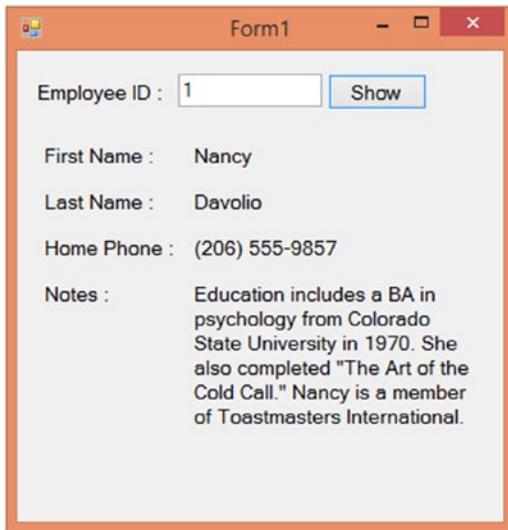


Figure 4-8. Obtaining *XmlReader* from *XPathNavigator*

The application consists of a text box for entering the employee ID, a button, and nine labels. Upon clicking the Show button, the form displays the employee details on the form.

Listing 4-8 shows the Click event handler of the Show button.

Listing 4-8. Calling the *ReadSubtree()* Method

```
private void button1_Click(object sender, EventArgs e)
{
    XPathDocument doc=new XPathDocument("${Application.StartupPath}\\\employees.xml");
    XPathNavigator navigator = doc.CreateNavigator();
    navigator.MoveToRoot();
    navigator.MoveToFirstChild();

    while (navigator.MoveNext())
    {
        navigator.MoveToFirstChild();

        do
        {
            string id = navigator.GetAttribute("employeeid", "");
            if (id == textBox1.Text)
            {
                XmlReader reader=navigator.ReadSubtree();
                DisplayDetails(reader);
            }
        }
        while (navigator.MoveNext());
    }
}
```

The code begins by creating an instance of `XPathDocument`. An `XPathNavigator` is then obtained by calling `CreateNavigator()`. Then the code iterates through the document. The navigation logic should be familiar to you because we used it in previous examples. With each iteration, the `employeeid` attribute is checked against the value supplied from the text box. If they match, the `ReadSubtree()` method of `XPathNavigator` is called. In this case, this returns an instance of `XmlReader` that contains one `<employee>` node and all its child nodes. The returned `XmlReader` is passed to a helper function called `DisplayDetails()`, shown in Listing 4-9.

Listing 4-9. `DisplayDetails()` Helper Function

```
private void DisplayDetails(XmlReader reader)
{
    while (reader.Read())
    {
        if (reader.NodeType == XmlNodeType.Element)
        {
            switch (reader.Name)
            {
                case "firstname":
                    label6.Text = reader.ReadString();
                    break;
                case "lastname":
                    label7.Text = reader.ReadString();
                    break;
                case "homephone":
                    label8.Text = reader.ReadString();
                    break;
                case "notes":
                    label9.Text = reader.ReadString();
                    break;
            }
        }
    }
    reader.Close();
}
```

The `DisplayDetails()` function iterates through the supplied `XmlReader` object, calling its `Read()` method. With each iteration, the values of the `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>` nodes are retrieved by using the `ReadString()` method of the `XmlReader` class and assigned to the labels. Finally, the reader is closed by calling its `Close()` method.

Note The position of `XPathNavigator` remains unaffected even after calling the `ReadSubtree()` method.

Getting an XmlWriter from XPathNavigator

Just as you can create an `XmlReader` from `XPathNavigator`, you can also create an `XmlWriter` from it. This is useful in situations where you want to write selected nodes from `XPathNavigator` to a file or stream. `XPathNavigator` provides a method called `WriteSubtree()` that accepts an `XmlWriter` and writes the current node to it.

To illustrate the use of this technique, you need to develop an application like the one shown in Figure 4-9.

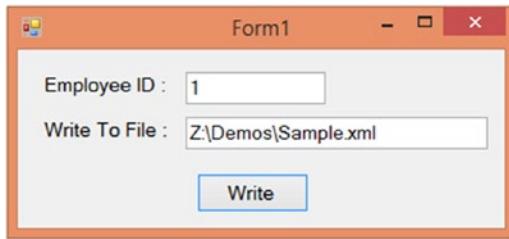


Figure 4-9. Obtaining an `XmlWriter` from `XPathNavigator`

The application consists of two text boxes: one to accept the employee ID to be extracted, and the other to specify a file path where the extracted employee details are stored.

Listing 4-10 shows the Click event handler of the Write button.

Listing 4-10. Calling the `WriteSubtree()` Method

```
private void button1_Click(object sender, EventArgs e)
{
    XPathDocument doc =
        new XPathDocument($"{Application.StartupPath}\\employees.xml");
    XPathNavigator navigator = doc.CreateNavigator();
    navigator.MoveToRoot();
    navigator.MoveToFirstChild();

    while (navigator.MoveNext())
    {
        navigator.MoveToFirstChild();

        do
        {
            string id = navigator.GetAttribute("employeeid", "");
            if (id == textBox1.Text)
            {
                XmlTextWriter writer = new XmlTextWriter(textBox2.Text, null);
                navigator.WriteSubtree(writer);
                writer.Close();
            }
        }
        while (navigator.MoveToNext());
    }
}
```

```

if (MessageBox.Show("Do you want to see the file?",
                    "Question",
                    MessageBoxButtons.YesNo) == DialogResult.Yes)
{
    System.Diagnostics.Process.Start(textBox2.Text);
}
}
while (navigator.MoveNext());
}
}

```

The code creates an instance of `XPathDocument` and `XPathNavigator` as before. It then starts navigating the document and finds the matching `<employee>` node. After the matching employee is found, the code creates an instance of `XmlTextWriter` (recollect that `XmlTextWriter` inherits from the `XmlWriter` abstract class), supplying the file path entered in the text box to the constructor. Though our example writes the data to a disk file, any writable stream can be used.

To write the matching employee to `XmlTextWriter`, the code calls the `WriteSubtree()` method of `XPathNavigator`. The `WriteSubtree()` method accepts any class derived from the `XmlWriter` base class and writes the contents of the current node to it. In our example, it will be the `<employee>` node and its child nodes. After the writing is over, the `XmlTextWriter` is closed by calling its `Close()` method. The code then asks the user whether to open the resultant file, as shown in Figure 4-10.

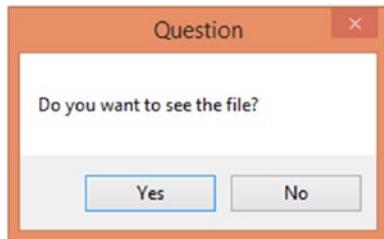
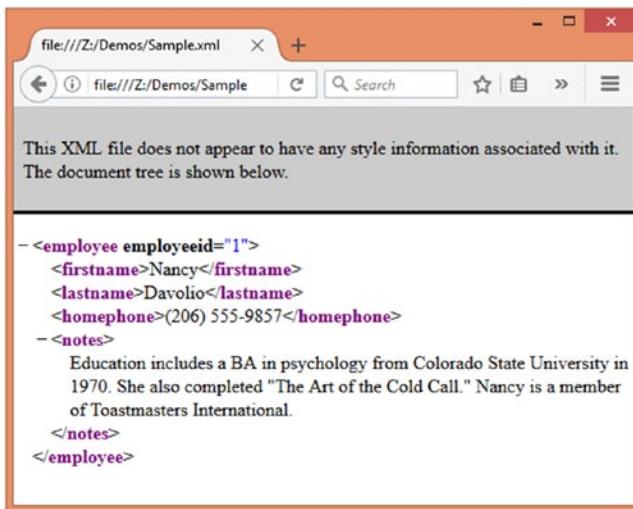


Figure 4-10. Prompting the user to open the resultant file

If the user clicks Yes, the resultant XML file is opened in the browser. Note the use of the `Process` class from the `System.Diagnostics` namespace. The `Start()` method of this class accepts a filename and opens it in its associated application. Figure 4-11 shows a sample output document with the `<employee>` subtree extracted.

**Figure 4-11.** Resultant XML document

Editing XML Documents with the XPathNavigator Class

Up until now, we have used `XPathNavigator` to navigate and read values from the underlying XML document. However, it is possible to modify the underlying document also, though the `XPathNavigator` must be obtained from the `XmlDocument` class to do so. `XPathNavigator` instances obtained from `XPathDocument` are read-only and hence cannot be used for editing. You can check whether an instance of `XPathNavigator` is editable by using its `CanEdit` property, which returns true if the instance is editable, and false otherwise.

To see how an XML document can be modified with the help of `XPathNavigator`, you need to develop an application like the one shown in Figure 4-12.

Employee ID :	<input type="text" value="1"/>	<input type="button" value="Show"/>
First Name :	<input type="text" value="Nancy"/>	
Last Name :	<input type="text" value="Davolio"/>	
Home Phone :	<input type="text" value="(206) 555-9857"/>	
Notes :	<div style="border: 1px solid black; padding: 5px;"> Education includes a BA in psychology from Colorado State University in 1970. She also completed "The Art of the Cold Call." Nancy is a </div>	
<input type="button" value="Add"/> <input type="button" value="Update"/> <input type="button" value="Delete"/> <input type="button" value="Save"/>		

Figure 4-12. Modifying an XML document by using `XPathNavigator`

The application consists of text boxes to supply values for employee ID, first name, last name, home phone, and notes. There are four buttons for adding a new employee, modifying an existing employee, deleting an existing employee, and saving the changed document, respectively. When you enter an employee ID and click the Show button, the details of that employee are displayed in the remaining text boxes. You can change the details as per your requirements and click the Add, Update, or Delete buttons to add, update, or delete an employee, respectively. To save the modified document, you need to click the Save button.

In the source code of the application, you will find two form variables declared, as shown Listing 4-11.

Listing 4-11. Declaring XmlDocument and XPathNavigator

```
XmlDocument doc = new XmlDocument();
XPathNavigator navigator = null;
```

The Employees.xml file is loaded into this XmlDocument, and an XPathNavigator is obtained from it. This code goes in the Load event of the form and is shown in Listing 4-12.

Listing 4-12. Creating XPathNavigator

```
private void Form1_Load(object sender, EventArgs e)
{
    doc.Load($"{Application.StartupPath}\\employees.xml");
    navigator = doc.CreateNavigator();
}
```

When the user enters an employee ID and clicks the Show button, the details of that employee need to be displayed in the remaining text boxes. The Click event handler of the Show button does this job, as shown in Listing 4-13.

Listing 4-13. Retrieving Details of an Employee

```
private void button1_Click(object sender, EventArgs e)
{
    navigator.MoveToRoot();
    navigator.MoveToFirstChild();

    while (navigator.MoveNext())
    {
        navigator.MoveToFirstChild();

        do
        {
            string id = navigator.GetAttribute("employeeid", "");
            if (id == textBox1.Text)
            {
                navigator.MoveToFirstChild();
                do
                {
                    switch (navigator.Name)
                    {
                        case "firstname":
                            textBox2.Text = navigator.Value;
                            break;
```

```

        case "lastname":
            textBox3.Text = navigator.Value;
            break;
        case "homephone":
            textBox4.Text = navigator.Value;
            break;
        case "notes":
            textBox5.Text = navigator.Value;
            break;
    }
}
while (navigator.MoveNext());
navigator.MoveToParent();
}
}
while (navigator.MoveNext());
}
}

```

The code should be familiar to you, because we used something similar in previous examples. The code loops through all the `<employee>` nodes and finds the one that matches the supplied employee ID. The values of various child nodes such as `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>` are displayed in the respective text boxes by using the `Value` property of `XPathNavigator`.

Adding Nodes

To add new nodes to the document, the `XPathNavigator` class provides a method called `AppendChild()`. The `AppendChild()` method returns an instance of `XmlWriter`, and by using this `XmlWriter` you can write additional nodes to the document. The newly written nodes are added as child nodes of the current node. Listing 4-14 shows how this is accomplished.

Listing 4-14. Appending New Nodes

```

private void button2_Click(object sender, EventArgs e)
{
    navigator.MoveToRoot();
    navigator.MoveToFirstChild();

    while (navigator.MoveNext())
    {
        XmlWriter writer = navigator.AppendChild();
        writer.WriteStartElement("employee");
        writer.WriteAttributeString("employeedid", textBox1.Text);
        writer.WriteString("firstname", textBox2.Text);
        writer.WriteString("lastname", textBox3.Text);
        writer.WriteString("homephone", textBox4.Text);
        writer.WriteString("notes", textBox5.Text);
        writer.WriteEndElement();
        writer.Close();
    }
}

```

The code first navigates to the `<employees>` node. This is where we want to add a new `<employee>` child node. Then it calls the `AppendChild()` method of the `XPathNavigator`. The returned `XmlWriter` is used to add a new `<employee>` node with an `employeeid` attribute.

The child nodes of the `<employee>` node (`<firstname>`, `<lastname>`, `<homephone>`, and `<notes>`) are also added. The methods such as `WriteStartElement()` and `WriteEndElement()` should already be familiar to you from Chapter 3.

Note There are a few other overloads of the `AppendChild()` method. For example, one overload accepts the complete XML markup fragment for the new node and appends it to the current node. However, the one that we used is more flexible.

Modifying Nodes

To modify contents of any of the nodes, the `XPathNavigator` class provides a method called `SetValue()`, which accepts the new value and assigns it to the current node. Listing 4-15 shows how this method can be used.

Listing 4-15. Modifying Content

```
private void button3_Click(object sender, EventArgs e)
{
    navigator.MoveToRoot();
    navigator.MoveToFirstChild();

    while (navigator.MoveNext())
    {
        navigator.MoveToFirstChild();

        do
        {
            string id = navigator.GetAttribute("employeeid", "");
            if (id == textBox1.Text)
            {
                navigator.MoveToFirstChild();

                do
                {
                    switch (navigator.Name)
                    {
                        case "firstname":
                            navigator.SetValue(textBox2.Text);
                            break;
                        case "lastname":
                            navigator.SetValue(textBox3.Text);
                            break;
                        case "homephone":
                            navigator.SetValue(textBox4.Text);
                            break;
                    }
                }
            }
        }
    }
}
```

```

        case "notes":
            navigator.SetValue(textBox5.Text);
            break;
    }
}
while (navigator.MoveNext());

navigator.MoveToParent();
}
}
while (navigator.MoveNext());
}
}

```

As before, the code finds out the <employee> node that is to be updated. The switch statement checks the Name property of XPathNavigator for the required node names (firstname, lastname, homephone, and notes). Inside each case, the SetValue() method is called on the navigator by passing the new value from the appropriate text box.

Deleting Nodes

Deleting a node is fairly simple. The DeleteSelf() method of XPathNavigator deletes the current node. After the node is successfully deleted, the cursor is moved to the parent node of the deleted node. Listing 4-16 shows the usage of DeleteSelf().

Listing 4-16. Deleting a Node

```

private void button4_Click(object sender, EventArgs e)
{
    navigator.MoveToRoot();
    navigator.MoveToFirstChild();

    while (navigator.MoveNext())
    {
        navigator.MoveToFirstChild();

        do
        {
            string id = navigator.GetAttribute("employeeid", "");
            if (id == textBox1.Text)
            {
                navigator.DeleteSelf();
            }
        }
        while (navigator.MoveNext());
    }
}

```

As in the previous case, the code looks for a specific <employee> node. After it finds the node, it calls the DeleteSelf() method on the navigator.

Saving Changes

It is important to remember that while making any modifications via `XPathNavigator`, the changes are not saved automatically to disk. The changes affect only the DOM tree loaded in memory, so you need to save the underlying document by calling the `Save()` method of the `XmlDocument` class. This is illustrated in Listing 4-17.

Listing 4-17. Saving the Document

```
private void button5_Click(object sender, EventArgs e)
{
    doc.Save(${Application.StartupPath}\employees.xml");
}
```

Summary

In this chapter, you learned what XPath is and how to use XPath expressions in the .NET Framework. We covered in detail the `XPathNavigator` class, which provides a cursor-like model for the XPath data model of the .NET Framework. The `XPathNavigator` class can be constructed from either of the `XPathDocument` or `XmlDocument` classes. The `XPathNavigator` returned from `XPathDocument` is read-only, whereas that returned from `XmlDocument` is editable. You also learned how to select nodes from the XML document by using XPath expressions in string form as well as in compiled form.

CHAPTER 5



Validating XML Documents

In Chapters 2, 3, and 4, you learned how to read and write XML documents, though we always assumed that the XML structure (tag names, attribute names, nesting, and so on) contained in the source XML document was correct. However, in many real-world cases this assumption may not be true. For example, a purchase order application might be accepting orders from various customers in XML format. What is the guarantee that each submitted order adheres to the agreed-on XML structure? What if somebody deviates from the agreed-on structure? This is where XML Schema comes into the picture.

XML Schema describes the structure of an XML document; to use an analogy, they serve the same purpose as database schemas. For example, schema of a database table tells you what columns it has, what are their data types, whether they can contain NULL, and so on. XML Schema does something similar for XML documents. With the help of a schema, you can do the following important things:

- You can define metadata—elements, attributes, types and so on—for XML documents.
- You can create XML documents based on the schema.
- You can validate XML documents against the schema.

In this chapter, you learn about the following:

- Various ways to define the structure of an XML document
- What XML Schema is
- How to create XML Schema
- How to validate XML documents against a schema
- How to create schemas programmatically by using the Schema Object Model (SOM)

Providing Structure for XML Documents

As mentioned previously, XML Schema defines the structure of an XML document. In other words, it provides a template, consisting of metadata, for creating and validating XML documents. However, a schema is not the only way to provide structure for an XML document. The .NET Framework supports three ways of defining XML structure:

- Document Type Definition (DTD)
- XML Data Reduced (XDR) Schema
- XML Schema Definition (XSD) Schema

Document Type Definition (DTD)

DTDs are an older way of representing XML structure, but they are still in use. They are a W3C standard, and older applications depend on them for validation. A DTD defines the overall structure of an XML document in terms of acceptable tag names, acceptable attribute names, and so on. An XML document author uses the DTD while creating a document. The same DTD can be used while validating the document also. You should avoid using DTDs in modern applications since they suffer from many disadvantages:

- They use non-XML syntax.
- They are difficult to create as well as to understand.
- You need to specifically learn the DTD syntax.
- They are not extensible.
- They do not support data types.
- They do not support namespaces.

XML Data Reduced (XDR) Schema

While the XSD Schema proposal (discussed next) was under consideration, Microsoft went ahead and created its implementation, called the XML Data Reduced, or XDR, schema specification. However, the XDR Schema specification and the XSD Schema specification are not the same. For the sake of backward compatibility, Microsoft retained support for XDR Schemas in the .NET Framework. If you are creating a new schema for your XML documents, you should use the XSD Schema specification instead of XDR.

XML Schema Definition (XSD) Schema

XSD schema specification or XML Schema is the result of efforts to provide standardization for defining XML structures. The XSD specification is a W3C recommendation. One of the key benefits of XSD is that it supports data types. XSD is an XML document itself and overcomes most of the limitations of DTD. If you are building new schemas for your XML documents, you should create them by using XSD instead of the DTD or XDR standards. XSD has largely superseded DTD and other ways of defining XML document metadata.

Creating Structure for an XML Document

Now that you know the possible ways to define XML structure, let's put each of the ways to use. In this section, you will create a formal structure for the same `Employees.xml` document by using the DTD and XSD standards. Because XDR is now considered an outdated standard, I will not cover XDR here.

The Structure of `Employees.xml`

You already know how the `Employees.xml` file looks. Our aim is to define the structure of the document by using the DTD and XSD standards so that you can validate the document later. The structure of `Employees.xml` is as follows:

- The root element must be `<employees>`.
- The root element can contain zero or more `<employee>` elements.
- The `<employee>` element must have an attribute called `employeeid`.

- The `<employee>` element must contain `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>` sub-elements.
- The `<firstname>`, `<lastname>`, and `<homephone>` elements contain plain-text values.
- The `<notes>` element contains character data (CDATA).
- The `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>` sub-elements must appear in the same order.

Keeping the preceding requirements in mind, let's create the DTD first, followed by the XSD.

Creating the DTD

In this section, you learn how to create a DTD for representing the structure of the `Employees.xml` file. Listing 5-1 shows the complete DTD for the document.

Listing 5-1. DTD for `Employees.xml`

```
<!ELEMENT employees (employee*)>
<!ELEMENT employee (firstname,lastname,homephone,notes)>
<!ELEMENT firstname (#PCDATA)>
<!ELEMENT lastname (#PCDATA)>
<!ELEMENT homephone (#PCDATA)>
<!ELEMENT notes (#PCDATA)>
<!ATTLIST employee employeeid CDATA #REQUIRED>
```

The DTD defines the root element of the XML document to be `<employees>`. This is done by using the `<!ELEMENT>` declaration, which specifies the name of the element (`employees` in our case) and content that can go inside it. In our case, the `<employees>` element can take zero or more `<employee>` elements and not any other element or text. This constraint is enforced by placing the acceptable element names (`employee` in our case) in the brackets. The asterisk (*) indicates that zero or more `<employee>` elements can be placed inside an `<employees>` element. Similar to *, you can also use the plus sign (+) and question mark (?). The + operator indicates that you can have one or more occurrences of the element, whereas ? indicates that the element is optional.

Next we define the `<employee>` element by using the same `<!ELEMENT>` declaration. Because the `<employee>` element must contain `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>` sub-elements, they are specified as a comma-separated list. A comma-separated list of elements must appear in the order specified. If you want to allow the elements to appear in any order, you can use the pipe (|) character instead of the comma.

The document then defines each of the sub-elements of the `<employee>` element. To indicate that the elements contain plain character data and no other sub-elements, we use `#PCDATA`, which stands for *plain character data*. Thus, the DTD enforces that the `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>` elements can contain only plain character data and no markup or sub-elements. If our elements contained character data and sub-elements, we could have used ANY instead of `#PCDATA`. Along the same lines, if our elements are empty (that is, they contain neither character data nor sub-elements), we could have used `EMPTY`.

Finally, the DTD defines the `employeeid` attribute for the `<employee>` element by using the `<!ATTLIST>` declaration. The `<!ATTLIST>` declaration takes the element whose attributes are being defined, followed by a list of attributes. The `CDATA` in the markup indicates that the attribute value contains character data. You can mark the attribute as a unique identifier by specifying its type as ID. The `#REQUIRED` in the declaration indicates that this attribute is mandatory and must be provided in the document.

Note Recollect that in Chapter 2 we used the `GetElementById()` method of the `XmlDocument` class. This method requires that the element to search should have an attribute of type `ID`.

To create the DTD, you can use the Visual Studio IDE. Add a new text file, but name it `Employees.dtd`. Type in the entire markup shown in Listing 5-1 and save the file. Open `Employees.xml` in the Visual Studio IDE and add a DOCTYPE declaration to it at the top, as shown in Listing 5-2.

Listing 5-2. Attaching the DTD to an XML Document

```
<?xml version="1.0" encoding="utf-8" ?>
<!DOCTYPE employees SYSTEM "employees.dtd">
<employees>
    <employee employeeid="1">
        <firstname>Nancy</firstname>
        ...
    </employee>
</employees>
```

As you can see, at the top of the XML file, we have put the `<!DOCTYPE>` declaration. The `<!DOCTYPE>` declaration is used to attach a DTD to an XML file. The `<!DOCTYPE>` declaration is immediately followed by `<employees>`—the root element of the document. The `SYSTEM` identifier specifies the URI of the DTD file that is providing structure to this XML document. In our case, it is `employees.dtd` (it is assumed that the XML document and the DTD are in the same folder).

Note Just like the `SYSTEM` identifier, there is `PUBLIC` identifier that is used to specify a well-known public schema that can be used by many applications. The `SYSTEM` identifier, on the other hand, is used to specify a schema that is specific to an application (for example, `employees.dtd` in our case).

You might be wondering why we created the DTD in Visual Studio. Apart from providing IntelliSense, it is not helping much, is it? But wait a moment before you conclude anything, because it has something more to offer. Now add a new XML file in your project, and then add to it the `<!DOCTYPE>` declaration shown in Listing 5-2. When you start creating the document, you will observe that the IDE shows various elements and attributes in IntelliSense. Figure 5-1 shows how this IntelliSense looks.

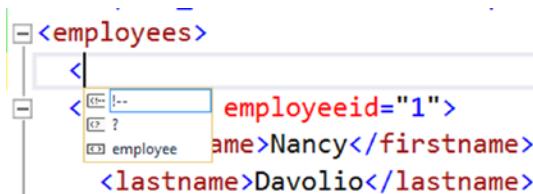


Figure 5-1. Visual Studio IntelliSense for DTDs

The IDE also validates your document as you type. It displays error messages if you enter markup or attributes that violate the DTD rules.

Creating the XML Schema

In this section, you learn how to create XSD Schemas in three ways:

- Creating the XML Schema by using the Visual Studio IDE
- Creating the XML Schema from an existing XML document using the Visual Studio IDE
- Creating the XML Schema by using the `xsd.exe` command-line tool (often called the XML Schema Definition tool)

An XML Schema is typically stored in a file with the extension `.xsd`. A schema consists of various parts, some of which are listed in Table 5-1.

Table 5-1. Parts of an XSD Schema

Part Name	Description
Element	Represents a single element.
Attribute	Represents a single attribute of an element.
Attribute group	Represents a group of attributes that can be used further in a complex type.
Simple type	A simple type consists of only text values and no sub-elements—for example, string, numbers, date, and so on. Elements as well as attributes can be of the simple type.
Complex type	A complex type consists of one or more simple types. Only elements can be of the complex type.

One of the key advantages of XSD schemas over DTDs is that they support data types. These data types map with the .NET Framework's data types; thus, XSD data types can be represented by their equivalent data types in the .NET Framework. Table 5-2 lists some of the common XSD data types and their .NET counterparts.

Table 5-2. XSD Data Types

XSD Data Type	.NET Data Type	Description
Boolean	<code>System.Boolean</code>	Represents Boolean values (<code>true</code> or <code>false</code>)
Byte	<code>System.SByte</code>	Represents an 8-bit signed integer (byte)
dateTime	<code>System.DateTime</code>	Represents the date and time
decimal	<code>System.Decimal</code>	Represents a decimal number
Double	<code>System.Double</code>	Represents a double precision number
Float	<code>System.Single</code>	Represents a single precision floating number
Int	<code>System.Int32</code>	Represents a 4-byte signed integer
Long	<code>System.Int64</code>	Represents an 8-byte signed integer
String	<code>System.String</code>	Represents string data

Now that you have a brief idea about XSD schemas, their parts, and data types, we will proceed to create XSD schemas by using the various ways described.

XSD for Employees.xml

To create any XML Schema, you first need to think about the simple types, complex types, elements, and attributes that go into it. Let's do this exercise for the `Employees.xml` file.

We will create three simple types for `Employees.xml`:

- `NameSimpleType`: This simple type represents names used in our XML document (first name and last name). It puts restrictions on the names: the minimum length must be three, and the maximum length must be less than 255.
- `PhoneSimpleType`: This simple type represents phone numbers (the `<homephone>` element of our XML document). It restricts the phone numbers to no more than 20 characters.
- `NotesSimpleType`: This simple type represents notes (the `<notes>` element of our document). It restricts the notes entered to no longer than 500 characters in length.

These three simple types will make a complex type called `EmployeeType`. The `EmployeeType` complex type consists of the following:

- An element called `<firstname>`, which is of simple type `NameSimpleType`
- An element called `<lastname>`, which is of simple type `NameSimpleType`
- An element called `<homephone>`, which is of simple type `PhoneSimpleType`
- An element called `<notes>`, which is of simple type `NotesSimpleType`
- A required attribute called `employeeid`, which is of type `int`

Finally, we will have an element called `<employees>` that will contain zero or more sub-elements named `<employee>`. The `<employee>` sub-elements will be of complex type `EmployeeType`.

Creating the XSD in Visual Studio Designer

Creating an XML Schema in Visual Studio is easy, because the IDE provides visual tools to create, edit, and explore an XML Schema. To create a new XML Schema, you need to add one to your project by using the Add New Item dialog box. Name the new schema file `Employees.xsd`. Figure 5-2 shows the Add New Item dialog box with the relevant selection.

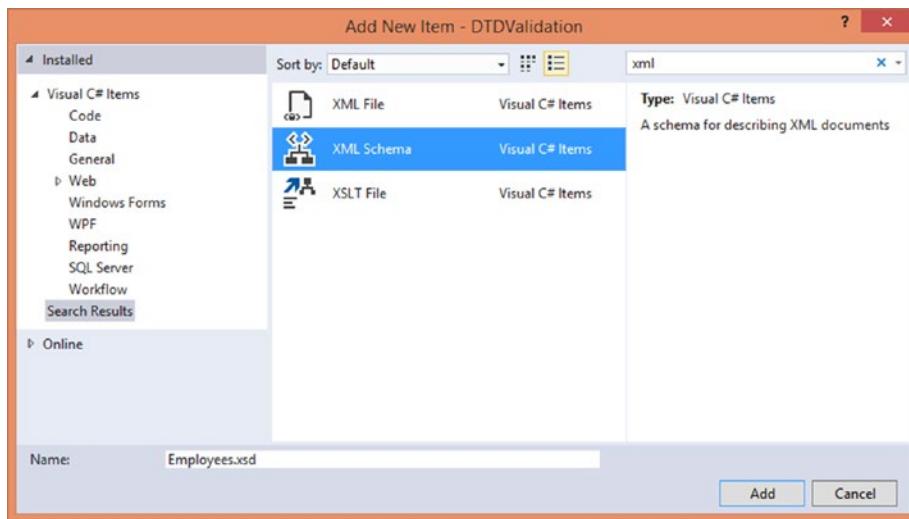


Figure 5-2. Adding a new XML Schema to your project

After you have added an XML Schema, you will be presented with the XML Schema Designer or XSD Designer. The XSD Designer is shown in Figure 5-3.

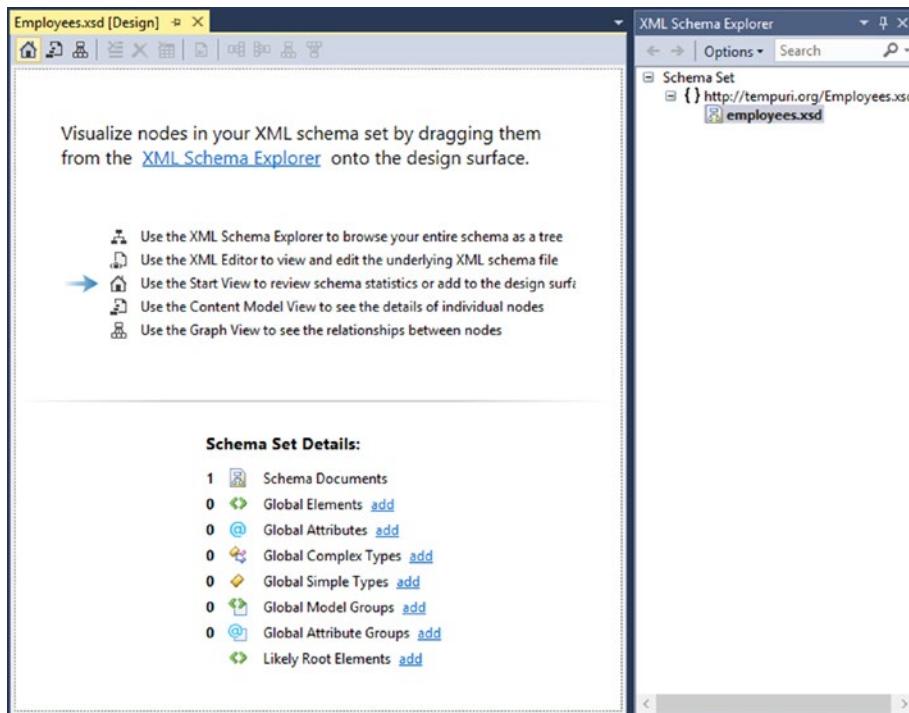


Figure 5-3. The XSD Designer of Visual Studio

As you can see in Figure 5-3, the XSD Designer consists of XML Schema Explorer and a few views. It also links to the XML Editor for the sake of editing the schema. Let's quickly see the purpose of each:

- *XML Schema Explorer*: The XML Schema Explorer presents a tree structure of your schema. You can then browse, navigate, and look for nodes.
- *XML Editor*: The XML Editor is where you create and edit your XSD. Since XSD is an XML document itself, the same XML Editor that you used for creating XML documents can be used to create an XSD too.
- *Start View*: The Start View acts like a home page and simply allows you to switch to other views or Schema Explorer.
- *Content Model View*: The Content Model View allows you look at the schema nodes and their parts such as simple types, complex types, elements, and attributes, graphically.
- *Graph View*: The Graph View allows you to look at the schema nodes and their relationship graphically for the sake of easy visualization and understanding.

Note Detailed coverage of the XSD Designer is beyond the scope of this book. MSDN documentation contains detailed explanation of each of the parts mentioned here. For our purposes, the XML Editor is sufficient.

Now that you have added Employees.xsd, click on the XML Editor option from the Start View of the XSD Designer. This will open the XML Editor, as shown in Figure 5-4.



Figure 5-4. XML Editor ready for creating an XSD

Now, write the markup from Listing 5-3 in the XML Editor.

Listing 5-3. XML Schema for Employees.xml

```

<?xml version="1.0" encoding="utf-8"?>
<xs:schema attributeFormDefault="unqualified"
    elementFormDefault="qualified"
    xmlns:xs="http://www.w3.org/2001/XMLSchema">
    <xss:element name="employees">
        <xss:complexType>

```

```

<xs:sequence>
  <xs:element name="employee" type="EmployeeType" minOccurs="0"
              maxOccurs="unbounded" />
</xs:sequence>
</xs:complexType>
</xs:element>
<xs:complexType name="EmployeeType">
  <xs:all>
    <xs:element name="firstname" type="NameSimpleType" />
    <xs:element name="notes" type="NotesSimpleType" />
    <xs:element name="lastname" type="NameSimpleType" />
    <xs:element name="homephone" type="PhoneSimpleType" />
  </xs:all>
  <xs:attribute name="employeeid" type="xs:int" use="required" />
</xs:complexType>
<xs:simpleType name="NameSimpleType">
  <xs:restriction base="xs:string">
    <xs:minLength value="3" />
    <xs:maxLength value="255" />
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="PhoneSimpleType">
  <xs:restriction base="xs:string">
    <xs:maxLength value="20" />
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="NotesSimpleType">
  <xs:restriction base="xs:string">
    <xs:maxLength value="500" />
  </xs:restriction>
</xs:simpleType>
</xs:schema>

```

The schema declaration starts with the `<schema>` tag. The XML namespace <http://www.w3.org/2001/XMLSchema> is required and indicates that this is an XML Schema. The `xmlns` attribute specifies that the namespace prefix for all the tags of this schema will be `xs`.

Then the schema declares the `<employees>` element by using the `<element>` tag. The `<employees>` element contains sub-elements named `<employee>`, which are of the complex type `EmployeeType`. The complex type is indicated by the `<complexType>` element. There can be zero or more occurrences of `<employee>` sub-elements as defined by the `minOccurs` and `maxOccurs` attributes, respectively. Note the use of the `unbounded` keyword to indicate that any number of the element can exist.

Next the schema defines a complex type called `EmployeeType` by using the `<complexType>` element. The `name` attribute of `<complexType>` indicates the name of the complex type being defined. The `EmployeeType` complex type consists of four sub-elements and one attribute. The elements are declared by using the `<element>` tag and its two attributes, `name` and `type`. The `name` attribute specifies the name of the element, whereas the `type` attribute indicates the data type of the element.

The attributes are declared by using the `<attribute>` tag. The `name` attribute of the `<attribute>` element specifies the name of the attribute, and the `type` attribute indicates the data type of the attribute. In our case, the `employeeid` attribute is of type `int` and is required, as indicated by the `use` attribute.

Then the schema defines the `NameSimpleType` simple type by using the `<simpleType>` element. Because we want the data type of `NameSimpleType` to be `string`, we indicated this in the `<restriction>` element. The minimum and maximum length of the element is decided by the `minLength` and `maxLength` attributes, respectively. In our case, the names must be more than 3 characters in length and should not exceed 255 characters.

The `PhoneSimpleType` simple type is defined next. It is a string not exceeding 20 characters. Finally, the `NotesSimpleType` simple type is defined. It is also a string, but it must not exceed 500 characters.

That's it! After you type in the preceding markup in the XML Editor, save the `Employees.xsd` file.

Before we move any further, let's quickly see how the nodes of `Employees.xsd` look in the XML Schema Explorer, Content Model View, and Graph View.

Click on the XML Schema Explorer link from the Start View so as to open the XML Schema Explorer (see Figure 5-5).

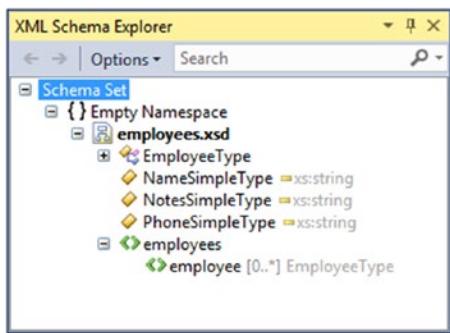


Figure 5-5. Employees.xsd in XML Schema Explorer

Notice how the `EmployeeType` complex type and `NameSimpleType`, `NotesSimpleType` and `PhoneSimpleType` simple types are shown. Also shown are the `employees` root element and zero or more occurrences of `employee` element.

If you click on the Content Model View and then drag-and-drop the `employees.xsd` node from the XML Schema Explorer, you will see something similar to Figure 5-6.

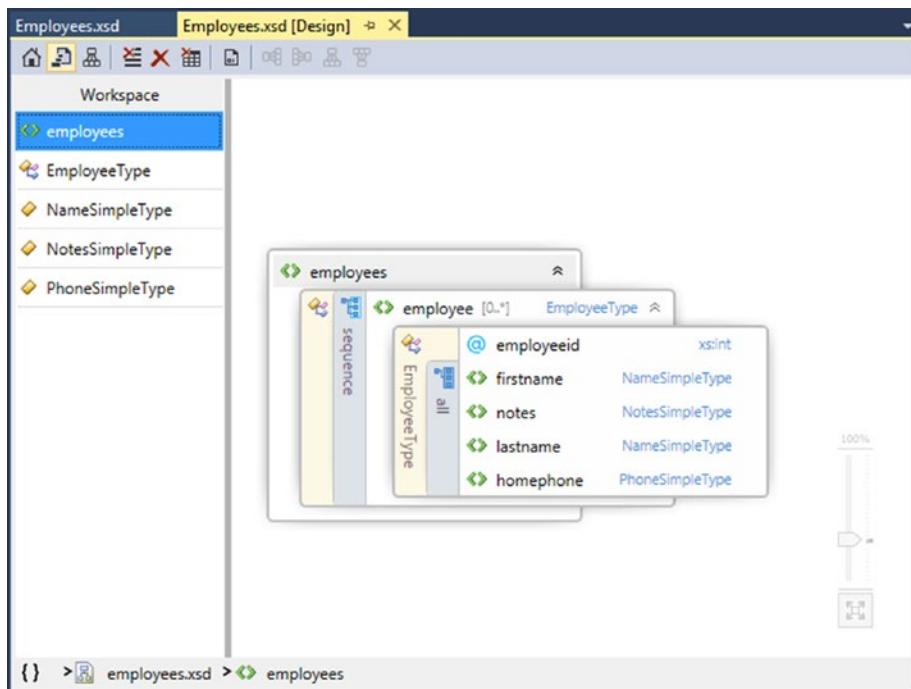


Figure 5-6. Viewing employees element in the Content Model View

Notice how the employees element, employee element, and other sub-elements are shown graphically. Of course, if you want to edit something you need to switch to the XML Editor again and make the desired change.

Figure 5-7 shows the various types and elements in the Graph View.

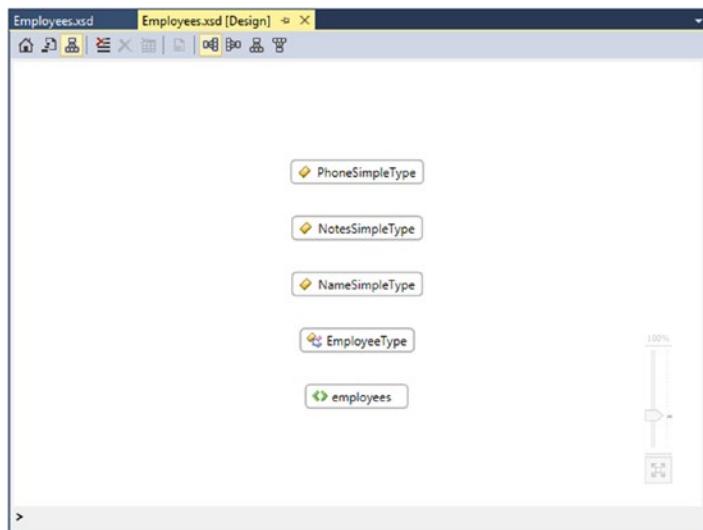


Figure 5-7. Various types and elements in the Graph View

Finally, have a look at the bottom part of the Start View. It lists a summary of the schema. Figure 5-8 shows these details for employees.xsd.

Schema Set Details:

1	Schema Documents
1	Global Elements add
0	Global Attributes add
1	Global Complex Types add
3	Global Simple Types add
0	Global Model Groups add
0	Global Attribute Groups add
	Likely Root Elements add

Figure 5-8. Summary of the schema as shown in the Start View

So far you created the XSD—employees.xsd. But it's not yet attached to the employees.xml. You will learn how to do that in later sections.

Creating the Schema from XML Document Using Visual Studio IDE

In the preceding section, you created the schema manually editing the employees.xsd file. This approach gives you total control on the XSD. At times, however, you already have XML documents ready and want to quickly create an XSD for them. Luckily, the Visual Studio IDE provides an easy way to do just that.

To see how the Visual Studio can do this for you, open the employees.xml file in the Visual Studio XML Editor. You will notice that the menu bar now has an extra menu—XML. Figure 5-9 shows this menu.

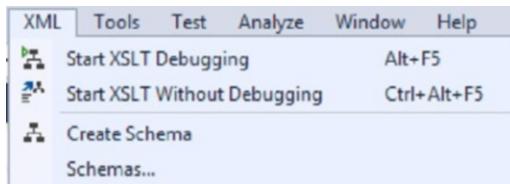


Figure 5-9. XML menu of Visual Studio

Notice that the XML menu has an option—Create Schema—that creates the schema for the open XML document. If you select this option while employees.xml is open, Visual Studio will generate a schema for you. Figure 5-10 shows the schema in the XML Schema Explorer.

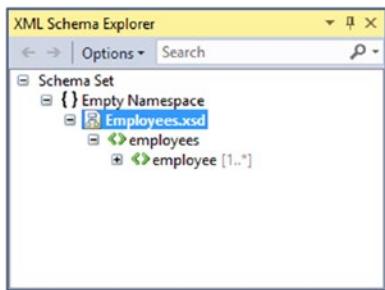


Figure 5-10. XML Schema Explorer showing the newly generated schema

If you observe the complete markup of the schema, it will resemble Listing 5-4.

Listing 5-4. Markup of the Newly Generated Schema

```
<?xml version="1.0" encoding="utf-8"?>
<xss:schema attributeFormDefault="unqualified"
elementFormDefault="qualified"
xmlns:xss="http://www.w3.org/2001/XMLSchema">
  <xss:element name="employees">
    <xss:complexType>
      <xss:sequence>
        <xss:element maxOccurs="unbounded" name="employee">
          <xss:complexType>
            <xss:sequence>
              <xss:element name="firstname" type="xss:string" />
              <xss:element name="lastname" type="xss:string" />
              <xss:element name="homephone" type="xss:string" />
              <xss:element name="notes" type="xss:string" />
            </xss:sequence>
            <xss:attribute name="employeeid" type="xss:unsignedByte" use="required" />
          </xss:complexType>
        </xss:element>
      </xss:sequence>
    </xss:complexType>
  </xss:element>
</xss:schema>
```

You will notice that the schema shown in Listing 5-4 takes care of the basic metadata such as element names, attributes, and their types. If you need customization, you will need to modify the XSD as per your needs.

Creating the Schema by Using the XML Schema Definition Tool

In the preceding section, you used the XML Schema Designer to create a schema. You also created a schema from an existing XML document. There is yet another way to create a schema—using the XML Schema Definition tool. The XML Schema Definition tool (xsd.exe) allows you to create XSD schemas from the following:

- An existing XML document
- An existing XDR Schema
- Types defined in an assembly (.exe or .dll)

The XML Schema Definition tool is provided as `xsd.exe` and can be invoked from the Visual Studio command prompt. In the following sections, you learn how to use this tool to create schemas from XML documents and assemblies.

Creating the Schema from an XML Document

Let's assume that you have the `Employees.xml` file with you and want to create XSD for it by using the `xsd.exe` command-line tool. To do so, open the Visual Studio command prompt. Then enter the following command at the command prompt:

```
xsd.exe "C:\Test\Employees.xml" /outputdir:"C:\Test"
```

The first parameter is the path and filename of the XML file for which the schema is to be generated. It is assumed that the `Employees.xml` file exists in the `C:\Test` folder. The `/outputdir` switch specifies the folder where the resultant XSD file should be created.

After you invoke the command, you will find an `.xsd` file in the specified folder. By default, the name of the schema file is the same as the XML filename. Listing 5-5 shows the schema generated by the tool.

Listing 5-5. Schema Generated by the `xsd.exe` Tool

```
<?xml version="1.0" encoding="utf-8"?>
<xss:schema id="employees" xmlns="" xmlns:xs="http://www.w3.org/2001/XMLSchema" ↵
  xmlns:msdata="urn:schemas-microsoft-com:xml-msdata">
  <xss:element name="employees" msdata:IsDataSet="true" ↵
    msdata:UseCurrentLocale="true">
    <xss:complexType>
      <xss:choice minOccurs="0" maxOccurs="unbounded">
        <xss:element name="employee">
          <xss:complexType>
            <xss:sequence>
              <xss:element name="firstname" type="xs:string" minOccurs="0" ↵
                msdata:Ordinal="0" />
              <xss:element name="lastname" type="xs:string" minOccurs="0" ↵
                msdata:Ordinal="1" />
              <xss:element name="homephone" type="xs:string" minOccurs="0" ↵
                msdata:Ordinal="2" />
              <xss:element name="notes" type="xs:string" minOccurs="0" ↵
                msdata:Ordinal="3" />
            </xss:sequence>
            <xss:attribute name="employeeid" type="xs:string" />
          </xss:complexType>
        </xss:element>
      </xss:choice>
    </xss:complexType>
  </xss:element>
</xss:schema>
```

As you can see, the resultant schema defines a root element called `<employees>`. The `<employees>` element can have zero or more occurrences of the `<employee>` element. The `<employee>` element is defined as a complex type and contains four sub-elements: `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>`. The schema also states that the elements must occur in the same sequence (as indicated by the `<sequence>` tag). The `employeeid` attribute is also defined. You can customize the generated schema to suit your needs.

Note You can also invoke the xsd.exe tool at a standard command prompt. However, you need to specify the complete path of the xsd.exe tool while invoking it. Alternatively, you can navigate to the installation folder of .NET where the tool is located and then invoke it. You can even add it to the PATH variable.

Creating the Schema from an Assembly

You might be wondering why you'd need to create a schema from an assembly. This facility, however, comes in handy during XML serialization, during which you often serialize your classes on the wire in XML format. Thus the XSD schema extracted from the assembly represents the metadata of this serialized XML.

Note You will learn more about XML serialization in Chapter 8.

To see how the xsd.exe tool can generate a schema from an assembly, we will create a class library project. The class library will have a single class called Employee. The source code of the Employee class is shown in Listing 5-6.

Listing 5-6. The Employee Class

```
namespace ClassLibrary1
{
    public class Employee
    {
        public int EmployeeID { get; set; }
        public string FirstName { get; set; }
        public string LastName { get; set; }
        public string HomePhone { get; set; }
        public string Notes { get; set; }
    }
}
```

The Employee class is quite straightforward and contains five public properties—EmployeeID, FirstName, LastName, HomePhone, and Notes.

After you create the class, make sure to compile it so that its assembly is outputted—ClassLibrary1.dll. Now invoke the xsd.exe tool as shown here:

```
xsd.exe "C:\ ClassLibrary1\bin\Debug\classlibrary1.dll"
/outputdir:"C:\ClassLibrary1"
```

The first parameter to xsd.exe specifies the path and filename of the assembly, whereas the /outputdir switch specifies the target folder where the XSD should be created. Listing 5-7 shows the XSD based on our Employee class.

Listing 5-7. Schema Generated for the Employee Class

```
<?xml version="1.0" encoding="utf-8"?>
<xss:schema elementFormDefault="qualified" ↴
xmlns:xss="http://www.w3.org/2001/XMLSchema">
    <xss:element name="Employee" nillable="true" type="Employee" />
```

```

<xss:complexType name="Employee">
  <xss:sequence>
    <xss:element minOccurs="1" maxOccurs="1" name="EmployeeID" type="xs:int" />
    <xss:element minOccurs="0" maxOccurs="1" name="FirstName" type="xs:string" />
    <xss:element minOccurs="0" maxOccurs="1" name="LastName" type="xs:string" />
    <xss:element minOccurs="0" maxOccurs="1" name="HomePhone" type="xs:string" />
    <xss:element minOccurs="0" maxOccurs="1" name="Notes" type="xs:string" />
  </xss:sequence>
</xss:complexType>
</xss:schema>

```

As you can see in Listing 5-7, the schema defines an element named `<Employee>` that is of complex type `Employee`. The complex type `Employee` contains five sub-elements: `<EmployeeID>`, `<FirstName>`, `<LastName>`, `<HomePhone>`, and `<Notes>`. As you must have guessed, the names of these elements are extracted from the names of the class properties. These elements must occur in sequence, as indicated by the `<sequence>` tag. As in the previous case, you can customize this schema to suit your needs.

Note When you use the preceding command, the tool generates a schema for all the classes in the assembly. You can specify only certain classes by using the `/type` switch. The `xsd.exe` tool can also create classes from a schema. This can be helpful for deserializing the XML data in a .NET application.

Creating Schemas by Using the Schema Object Model (SOM)

Up until now, we created schemas by using a variety of techniques, all of which were design-time techniques. That means we ourselves created the schemas by using a text editor, Visual Studio, or the `xsd.exe` tool. However, there is more to the show than this. The .NET Framework also allows you to create schemas programmatically.

You can load existing schemas or create a new one from the ground up. You can then manipulate the schema by adding or removing various parts such as elements, attributes, simple types, and complex types. After you manipulate the schema as per your requirements, you can then compile it. Compiling a schema ensures that there are no errors in the schema structure.

To perform schema manipulation, the .NET Framework provides a set of classes called the Schema Object Model, or SOM for short. The SOM classes reside in the `System.Xml.Schema` namespace. The SOM is for schemas what DOM is for XML documents: the SOM classes represent various parts of a schema. For example, to represent a simple type, the SOM provides a class called `XmlSchemaSimpleType`, and to represent an element, the SOM provides a class called `XmlSchemaElement`. There are many other classes that represent attributes, facets, groups, complex types, and so on.

In the following section, you learn about some of the core SOM classes. Note that the SOM is very extensive and I do not discuss every available class here.

The Core SOM Classes

Figure 5-11 shows the object hierarchy of the core SOM classes. As you can see, all the SOM classes inherit from an abstract base class called `XmlSchemaObject`. This class provides common base functionality to all the child classes.

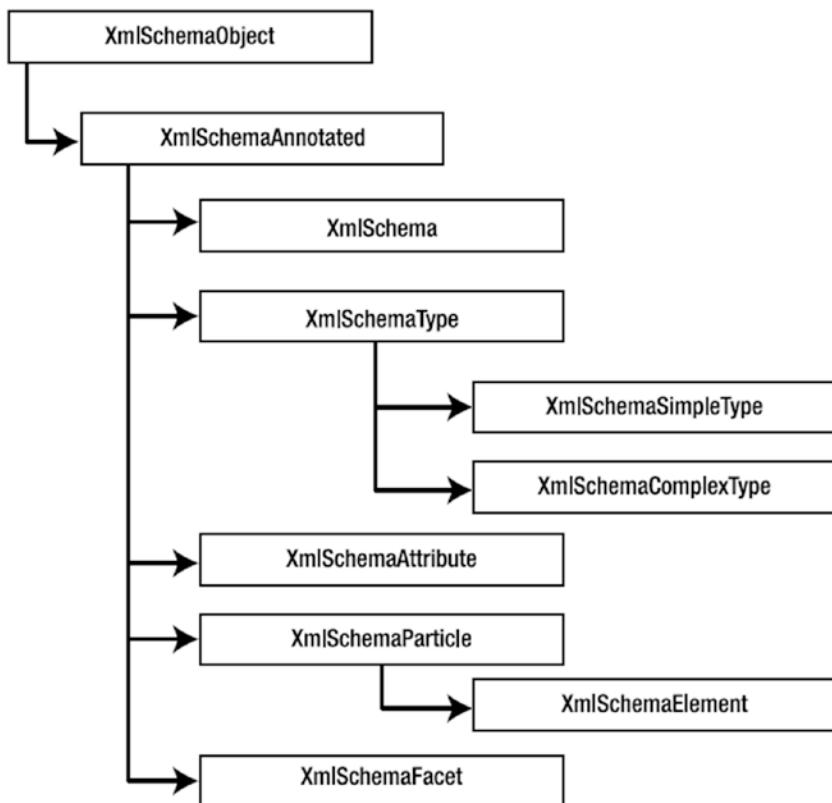


Figure 5-11. The SOM object hierarchy

The `XmlSchemaAnnotated` class represents a base class for any element that can contain annotation elements. Classes such as `XmlSchema`, `XmlSchemaType`, `XmlSchemaAttribute`, `XmlSchemaParticle`, and `XmlSchemaFacet` inherit from the `XmlSchemaAnnotated` class.

Note You can use annotation elements to provide information about the XML Schema. Annotations can appear anywhere in a schema to explain any element, attribute, or type definition.

The `XmlSchema` class represents an in-memory representation of an XML Schema. This class allows you to read, write, and compile XML Schemas.

The `XmlSchemaType` represents a type in an XML Schema and acts as a base class for all simple and complex types. The `XmlSchemaSimpleType` and `XmlSchemaComplexType` classes inherit from this class and allow you to define new simple and complex types, respectively.

The `XmlSchemaAttribute` represents an attribute of an element. Finally, the `XmlSchemaParticle` class provides base functionality to all particle types such as `XmlSchemaElement`.

Creating an XML Schema Using the SOM

Now that you know what the SOM is, let's put it to use to create a schema for our `Employees.xml` file. The schema will have three simple types:

- *Simple type for name*: This simple type represents names used in our XML document (first name and last name). It restricts the name length; the minimum length is 3 and the maximum length is less than 255.
- *Simple type for phone*: This simple type represents phone numbers (the `<homephone>` element of our XML document). It enforces a restriction requiring phone numbers to be no longer than 20 characters.
- *Simple type for notes*: This simple type represents notes (the `<notes>` element of our document). It enforces a restriction requiring the notes entered to be no longer than 500 characters.

These three simple types will make a complex type that represents an employee. The complex type consists of the following:

- An element called `<firstname>`, which is a name simple type
- An element called `<lastname>`, which is a name simple type
- An element called `<homephone>`, which is a phone simple type
- An element called `<notes>`, which is a notes simple type
- A required attribute called `employeeid`, which is of type `int`

Finally, we will have an element called `<employees>` that will contain zero or more sub-elements named `<employee>`. The `<employee>` sub-elements will be of the complex type I just mentioned.

To create the schema by using the SOM, you need to create a Windows application like the one shown in Figure 5-12.

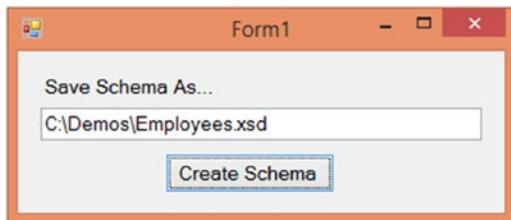


Figure 5-12. Application for creating a schema by using the SOM

The application consists of a text box wherein you can specify the full path and name of the destination schema file. Clicking the Create Schema button generates, compiles, and saves the schema to the specified location.

The Click event handler of the Create Schema button is shown in Listing 5-8.

Listing 5-8. Creating a Schema by Using the SOM

```

private void button1_Click(object sender, EventArgs e)
{
    XmlSchema schema = new XmlSchema();

    //define NameSimpleType
    XmlSchemaSimpleType nametype = new XmlSchemaSimpleType();
    XmlSchemaSimpleTypeRestriction nameRes = new XmlSchemaSimpleTypeRestriction();
    nameRes.BaseTypeName =
        new XmlQualifiedName("string", "http://www.w3.org/2001/XMLSchema");
    XmlSchemaMinLengthFacet nameFacet1 = new XmlSchemaMinLengthFacet();
    nameFacet1.Value = "3";
    XmlSchemaMaxLengthFacet nameFacet2 = new XmlSchemaMaxLengthFacet();
    nameFacet2.Value = "255";
    nameRes.Facets.Add(nameFacet1);
    nameRes.Facets.Add(nameFacet2);
    nametype.Content = nameRes;

    //define PhoneSimpleType
    XmlSchemaSimpleType phonetype = new XmlSchemaSimpleType();
    XmlSchemaSimpleTypeRestriction phoneRes = new XmlSchemaSimpleTypeRestriction();
    phoneRes.BaseTypeName =
        new XmlQualifiedName("string", "http://www.w3.org/2001/XMLSchema");
    XmlSchemaMaxLengthFacet phoneFacet1 = new XmlSchemaMaxLengthFacet();
    phoneFacet1.Value = "20";
    phoneRes.Facets.Add(phoneFacet1);
    phonetype.Content = phoneRes;

    //define NotesSimpleType
    XmlSchemaSimpleType notestype = new XmlSchemaSimpleType();
    XmlSchemaSimpleTypeRestriction notesRes = new XmlSchemaSimpleTypeRestriction();
    notesRes.BaseTypeName =
        new XmlQualifiedName("string", "http://www.w3.org/2001/XMLSchema");
    XmlSchemaMaxLengthFacet notesFacet1 = new XmlSchemaMaxLengthFacet();
    notesFacet1.Value = "500";
    notesRes.Facets.Add(notesFacet1);
    notestype.Content = notesRes;

    //define EmployeeType complex type
    XmlSchemaComplexType employeetype = new XmlSchemaComplexType();
    XmlSchemaSequence sequence = new XmlSchemaSequence();
    XmlSchemaElement firstname = new XmlSchemaElement();
    firstname.Name = "firstname";
    firstname.SchemaType = nametype;
    XmlSchemaElement lastname = new XmlSchemaElement();
    lastname.Name = "lastname";
    lastname.SchemaType = nametype;
    XmlSchemaElement homephone = new XmlSchemaElement();
    homephone.Name = "homephone";
    homephone.SchemaType = phonetype;
}

```

```

XmlSchemaElement notes = new XmlSchemaElement();
notes.Name = "notes";
notes.SchemaType = notestype;

sequence.Items.Add(firstname);
sequence.Items.Add(lastname);
sequence.Items.Add(homephone);
sequence.Items.Add(notes);
employeetype.Particle = sequence;

//define employeeid attribute
XmlSchemaAttribute employeeid = new XmlSchemaAttribute();
employeeid.Name = "employeeid";
employeeid.SchemaTypeName =
    new XmlQualifiedName("int", "http://www.w3.org/2001/XMLSchema");
employeeid.Use = XmlSchemaUse.Required;
employeetype.Attributes.Add(employeeid);

//define top complex type
XmlSchemaComplexType complextyppe = new XmlSchemaComplexType();
XmlSchemaSequence sq = new XmlSchemaSequence();
XmlSchemaElement employee = new XmlSchemaElement();
employee.Name = "employee";
employee.SchemaType = employeetype;
employee.MinOccurs = 0;
employee.MaxOccursString = "unbounded";
sq.Items.Add(employee);
complextyppe.Particle = sq;

//define <employees> element
XmlSchemaElement employees = new XmlSchemaElement();
employees.Name = "employees";
employees.SchemaType = complextyppe;

schema.Items.Add(employees);
//compile the schema
XmlSchemaSet set = new XmlSchemaSet();
set.Add(schema);
set.Compile();
//save the schema
XmlTextWriter writer = new XmlTextWriter(textBox1.Text,null);
schema.Write(writer);
writer.Close();
MessageBox.Show("Schema Created Successfully!");
}

```

The code is a bit lengthy and hence we will dissect it in pieces.

Creating the Schema

An in-memory schema is represented by the `XmlSchema` class. The code declares an instance of `XmlSchema` at the top:

```
XmlSchema schema = new XmlSchema();
```

Creating a Simple Type for Names

The schema needs to define a simple type for names. This is defined next:

```
XmlSchemaSimpleType nametype = new XmlSchemaSimpleType();
XmlSchemaSimpleTypeRestriction nameRes = new XmlSchemaSimpleTypeRestriction();
nameRes.BaseTypeName =
    new XmlQualifiedName("string", "http://www.w3.org/2001/XMLSchema");
XmlSchemaMinLengthFacet nameFacet1 = new XmlSchemaMinLengthFacet();
nameFacet1.Value = "3";
XmlSchemaMaxLengthFacet nameFacet2 = new XmlSchemaMaxLengthFacet();
nameFacet2.Value = "255";
nameRes.Facets.Add(nameFacet1);
nameRes.Facets.Add(nameFacet2);
nametype.Content = nameRes;
```

A simple type is represented by the `XmlSchemaSimpleType` class. The simple type for names has certain restrictions:

- The data type must be a string.
- The minimum length must be 3.
- The length must not exceed 255.

To represent these restrictions, an instance of the `XmlSchemaSimpleTypeRestriction` class is created. The `XmlSchemaSimpleTypeRestriction` class's `BaseTypeName` property, which is of type `XmlQualifiedName`, specifies the base data type used by this restriction. The `XmlQualifiedName` class can be used to represent built-in XSD data types such as `string` and `int`. In our example, we need `string` and hence we pass it as the first parameter of the constructor. The second parameter indicates the namespace to which the data type belongs. The minimum and maximum length restrictions can be enforced by facet classes.

The two facet classes we need are `XmlSchemaMinLengthFacet` and `XmlSchemaMaxLengthFacet`. These facet classes inherit from the `XmlSchemaFacet` base class and represent the minimum length and maximum length of the simple type, respectively, indicated by the `Value` property of each class. The facets are then added to the `XmlSchemaSimpleTypeRestriction` instance by using its `Add()` method. Finally, the `Content` property of the `XmlSchemaSimpleType` object is set to the restriction we created.

Creating a Simple Type for Phone Numbers

Creating a simple type for phone numbers follows the same procedure as discussed earlier. However, the restriction requirements are slightly different. The relevant code is shown here:

```
XmlSchemaSimpleType phonetype = new XmlSchemaSimpleType();
XmlSchemaSimpleTypeRestriction phoneRes = new XmlSchemaSimpleTypeRestriction();
phoneRes.BaseTypeName =
```

```

new XmlQualifiedName("string", "http://www.w3.org/2001/XMLSchema");
XmlSchemaMaxLengthFacet phoneFacet1 = new XmlSchemaMaxLengthFacet();
phoneFacet1.Value = "20";
phoneRes.Facets.Add(phoneFacet1);
phonetype.Content = phoneRes;

```

As before, instances of `XmlSchemaSimpleType` and `XmlSchemaSimpleTypeRestriction` are created. This time we need only one facet for specifying the maximum length of the phone number. Thus the code declares an instance of `XmlSchemaMaxLengthFacet` class and sets its `Value` property to 20. As before, the facet is added to the restriction, and the `Content` property of the `XmlSchemaSimpleType` instance is set to the phone number restriction.

Creating a Simple Type for Notes

Creating a simple type for notes is the same as I discussed earlier. The only change is in the maximum length value. The relevant code is shown here:

```

XmlSchemaMaxLengthFacet notesFacet1 = new XmlSchemaMaxLengthFacet();
notesFacet1.Value = "500";

```

Creating a Complex Type That Represents an Employee

A complex type is represented by the `XmlSchemaComplexType` class. In our example, the four sub-elements (`<firstname>`, `<lastname>`, `<homephone>`, and `<notes>`) must appear in the same sequence, which is defined by the `XmlSchemaSequence` class. The code that defines the complex type is shown here:

```

XmlSchemaComplexType employeetype = new XmlSchemaComplexType();
XmlSchemaSequence sequence = new XmlSchemaSequence();
XmlSchemaElement firstname = new XmlSchemaElement();
firstname.Name = "firstname";
firstname.SchemaType = nametype;
XmlSchemaElement lastname = new XmlSchemaElement();
lastname.Name = "lastname";
lastname.SchemaType = nametype;
XmlSchemaElement homephone = new XmlSchemaElement();
homephone.Name = "homephone";
homephone.SchemaType = phonetype;
XmlSchemaElement notes = new XmlSchemaElement();
notes.Name = "notes";
notes.SchemaType = notestype;

sequence.Items.Add(firstname);
sequence.Items.Add(lastname);
sequence.Items.Add(homephone);
sequence.Items.Add(notes);
employeetype.Particle = sequence;

//define employeeid attribute
XmlSchemaAttribute employeeid = new XmlSchemaAttribute();
employeeid.Name = "employeeid";

```

```

employeeid.SchemaTypeName =
    new XmlQualifiedName("int", "http://www.w3.org/2001/XMLSchema");
employeeid.Use = XmlSchemaUse.Required;
employeetype.Attributes.Add(employeeid);

```

This section of the code starts by declaring instances of the `XmlSchemaComplexType` and `XmlSchemaSequence` classes. Next we need four elements. Each is defined by an `XmlSchemaElement` class and should assume one of the simple types defined earlier. The `Name` property of the `XmlSchemaElement` class specifies the name of the element; the `SchemaType` property specifies the data type of the element and can be set to a simple type or a complex type. After all four elements are defined, they are added to the `XmlSchemaSequence` object by using its `Add()` method.

After the sequence instance is ready, you need to set the `Particle` property of the `XmlSchemaComplexType` object to it. The `Particle` property specifies the compositor type of the complex type, and an attribute of a complex type is represented by the `XmlSchemaAttribute` class. The `Name` property of `XmlSchemaAttribute` specifies the name of the attribute. The data type of the attribute is specified by using the `SchemaTypeName` property, which is of type `XmlQualifiedName`. In our case, the `employeeid` attribute is an integer and hence the `XmlQualifiedName` uses `int` as the data type. The `Use` property of the `XmlSchemaAttribute` class indicates how the attribute is used in the XML document. This property is an enumeration of type `XmlSchemaUse`. In our case, the `employeeid` attribute is mandatory and hence we set the `Use` property to `Required`.

Creating a Top-Level Complex Type

The root element of our XML document needs to have zero or more instances of the `<employee>` element, which is of the complex type we defined in the previous section. To represent the `<employee>` element, we define it as another complex type, as shown here:

```

XmlSchemaComplexType complextyp = new XmlSchemaComplexType();
XmlSchemaSequence sq = new XmlSchemaSequence();
XmlSchemaElement employee = new XmlSchemaElement();
employee.Name = "employee";
employee.SchemaType = employeetype;
employee.MinOccurs = 0;
employee.MaxOccursString = "unbounded";
sq.Items.Add(employee);
complextyp.Particle = sq;

```

The code creates an instance of the `XmlSchemaComplexType` and `XmlSchemaSequence` classes as before. This time it creates a single `XmlSchemaElement` to represent an `<employee>` element. This element is of type `employeetype` (the complex type we defined in the previous section).

The `MinOccurs` property of the `XmlSchemaElement` class indicates the minimum number of times the element must appear in the document. Along the same lines, the `MaxOccursString` property indicates the maximum permissible instances of the element. Note that this property accepts numbers as a string. If there is no restriction on the number, you can set it to unbounded. After the element is created, it is added to the sequence, and the sequence is assigned to the `Particle` property of the `XmlSchemaComplexType` class.

Creating the Root Element

The schema needs to have the `<employees>` root element that can contain one or more `<employee>` elements. The root element is defined as follows:

```
//define <employees> element
XmlSchemaElement employees = new XmlSchemaElement();
employees.Name = "employees";
employees.SchemaType = complextype;
```

As before, an instance of `XmlSchemaElement` is created. Its `Name` property is set to `employees`, and its `SchemaType` property is set to the top-level complex type we created in the previous section.

Compiling the Schema

Now we have completed all the simple types, complex types, and attributes. We can now add the root element to the schema. This is done by using the `Add()` method of the `Items` collection of the `XmlSchema` class:

```
schema.Items.Add(employees);
```

After the schema is ready, you can compile it. Compiling the schema ensures that the schema is syntactically correct and well formed. The `XmlSchemaSet` class represents a set of schemas and allows you to compile them. The relevant code is given here:

```
//compile the schema
try
{
    XmlSchemaSet set = new XmlSchemaSet();
    set.Add(schema);
    set.Compile();
}
catch (Exception ex)
{
    MessageBox.Show("Schema compilation failed");
    return;
}
```

The `Add()` method of the `XmlSchemaSet` class accepts the `XmlSchema` objects that are to be added to the schema set. The `Compile()` method of the `XmlSchemaSet` class compiles all the schemas in the given set.

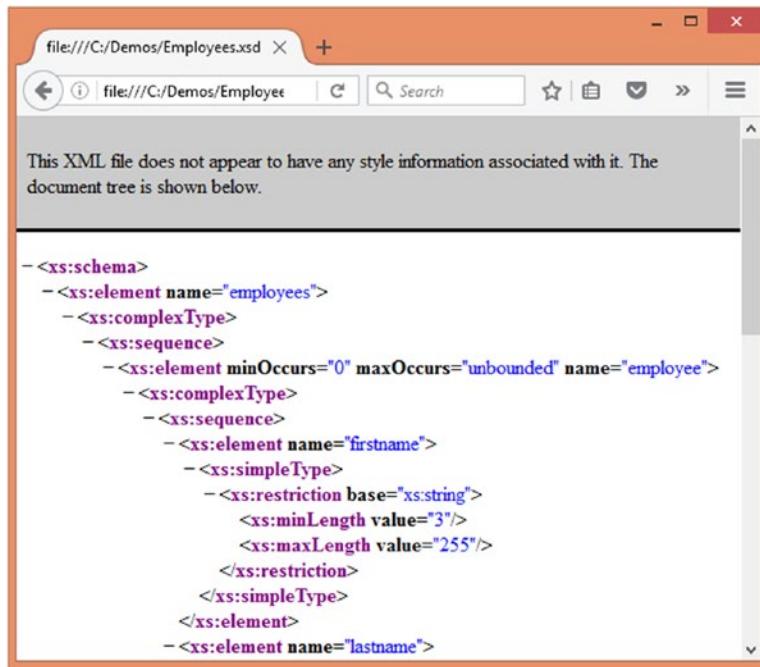
Saving the Schema

Now that we have created and compiled the schema, it is ready to be written to disk:

```
XmlTextWriter writer = new XmlTextWriter(textBox1.Text,null);
schema.Write(writer);
writer.Close();
```

The `Write()` method of the `XmlSchema` class writes the schema to a stream and has many overloads. We used one that accepts an `XmlWriter` pointing to the desired file. After the writing operation is over, the `XmlWriter` is closed.

That's it! You just created a complete schema using the SOM. You can run the application and see how the schema is generated. Figure 5-13 shows the resultant schema.



```

<xs:schema>
  <xs:element name="employees">
    <xs:complexType>
      <xs:sequence>
        <xs:element minOccurs="0" maxOccurs="unbounded" name="employee">
          <xs:complexType>
            <xs:sequence>
              <xs:element name="firstname">
                <xs:simpleType>
                  <xs:restriction base="xs:string">
                    <xs:minLength value="3"/>
                    <xs:maxLength value="255"/>
                  </xs:restriction>
                </xs:simpleType>
              </xs:element>
            <xs:element name="lastname">

```

Figure 5-13. Schema generated by using the SOM

Attaching the DTD and XML Schemas to XML Documents

Up until this point, you have learned what the DTD and XML Schemas are. You've also learned how to create the DTD and XML Schema. Now it's time to learn how to validate an XML document against the DTD and XML Schema.

Before you can validate an XML document, you must attach a DTD or XML Schema to it. The DTD or XML Schema can be attached via two techniques:

- *Inline DTD or XML schema:* In this technique, the DTD or schema is specified at the top of the XML document.
- *External DTD or XML schema:* In this technique, the DTD or schema resides in its own file—that is, it is external to the XML document. The DTD or schema is then attached to the XML document.

Inline DTDs

To specify a DTD in inline fashion, you need to add a `<!DOCTYPE>` declaration at the top of the XML document. Listing 5-9 shows how this is done for `Employees.xml`.

Listing 5-9. Inline DTD

```
<?xml version="1.0" encoding="utf-8" ?>
<!DOCTYPE employees [
<!ELEMENT employees (employee*)>
<!ELEMENT employee (firstname, lastname, homephone, notes)>
<!ELEMENT firstname (#PCDATA)>
<!ELEMENT lastname (#PCDATA)>
<!ELEMENT homephone (#PCDATA)>
<!ELEMENT notes (#PCDATA)>
<!ATTLIST employee employeeid CDATA #REQUIRED>
]>

<employees>
  <employee employeeid="1">
    <firstname>Nancy</firstname>
    <lastname>Davolio</lastname>
  ...

```

Notice the markup in bold: it is the same DTD that we created previously. However, this time it is placed inline with the XML document inside the `<!DOCTYPE>` declaration. Note that the `<!DOCTYPE>` declaration must precede the root element of the XML markup. Using inline DTDs comes in handy when your XML documents are small and you don't want to maintain separate DTD files.

External DTDs

External DTDs are stored in separate files, usually with the `.dtd` extension. The DTD is then linked to the XML document using a `<!DOCTYPE>` declaration. Listing 5-10 shows how this is done.

Listing 5-10. External DTD

```
<?xml version="1.0" encoding="utf-8" ?>
<!DOCTYPE employees SYSTEM "employees.dtd">
<employees>
  <employee employeeid="1">
    <firstname>Nancy</firstname>
    <lastname>Davolio</lastname>
  ...

```

When attaching an external DTD, the `<!DOCTYPE>` declaration is immediately followed by the name of the root element of the XML document (`employees` in our case). The `SYSTEM` declaration is followed by the URL of the DTD file. In the preceding example, it is assumed that the DTD resides in a file named `employees.dtd`.

Inline XML Schema

A schema can be specified inline by embedding it within the XML markup itself. As shown in Listing 5-11, the complete schema (starting from `<xss:schema>` to `<xss:/schema>`) is placed immediately inside the root element `<employees>`. The schema must be placed here because an XML document cannot have two root elements.

Listing 5-11. Inline XML Schema

```
<?xml version="1.0" encoding="utf-8" ?>
<employees>
  <xss:schema attributeFormDefault="unqualified" elementFormDefault="qualified"
    xmlns:xss="http://www.w3.org/2001/XMLSchema">
    <xss:element name="employees">
      <xss:complexType>
...

```

Though the XML Editor of Visual Studio supports inline schemas, as a programming recommendation, you should avoid using them. W3C recommendations allow inline schemas, but this support is not a mandatory feature. That means all vendors may not provide support for inline schemas. Further, because they are included within the XML document, they consume more network bandwidth as they are transferred across the wire every time.

External XML Schema

External schemas reside in a physical file, usually with the `.xsd` extension. To attach an external schema to an XML document, you need to modify the root element of the XML document, as shown in Listing 5-12.

Listing 5-12. External XML Schema

```
<?xml version="1.0" encoding="utf-8" ?>
<employees xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:noNamespaceSchemaLocation="employees.xsd">
  <employee employeeid="1">
    <firstname>Nancy</firstname>
    <lastname>Davolio</lastname>
...

```

As you can see, the `<employees>` root element now has an `xmns:xsi` attribute that specifies the W3C namespace for XML documents, which are referred to as *XML schema instances*. The `xsi:noNamespaceSchemaLocation` attribute specifies the URL of the schema file (`employees.xsd` in our case).

In the preceding example, our XML document doesn't use a namespace. If it did, we would have to make two changes to our schema and XML documents:

- Add the `targetNamespace` attribute to the schema declaration.
- Use the `xsi:schemaLocation` attribute instead of the `xsi:noNamespaceSchemaLocation` attribute.

Listing 5-13 shows the modified schema, and Listing 5-14 shows the modified XML document.

Listing 5-13. Schema with Target Namespace

```
<xss:schema
    attributeFormDefault="qualified"
    elementFormDefault="qualified"
    xmlns:xs="http://www.w3.org/2001/XMLSchema"
    targetNamespace="myns"
    xmlns="myns">
...

```

As you can see, the schema now has a `targetNamespace` attribute that specifies the target namespace as `myns`. The XML document must use this namespace, as illustrated in Listing 5-14.

Listing 5-14. XML Document with Namespace

```
<myns:employees
    xmlns:myns="myns"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="myns employeesns.xsd">
<myns:employee myns:employeeid="1">
<myns:firstname>Nancy</myns:firstname>
...

```

Note the markup in bold. The root element now declares a namespace called `myns`, and instead of `xsi:noNamespaceSchemaLocation` it now uses an `xsi:schemaLocation` attribute. Observe carefully how the attribute value is specified: it must contain the namespace name, a space, and then the URL of the XSD file.

Adding Frequently Used Schemas to the Schema Cache

If you find yourself using the same schema files again and again, you may consider adding your schema to the schema cache. Once you store a schema in the schema cache, you can access it readily in the XML Editor of Visual Studio. The schema cache can be seen from the **XML > Schemas** menu option of Visual Studio. Note that the XML menu option is visible only when you open an XML file in the Visual Studio Editor. Figure 5-14 shows the schemas available by default.

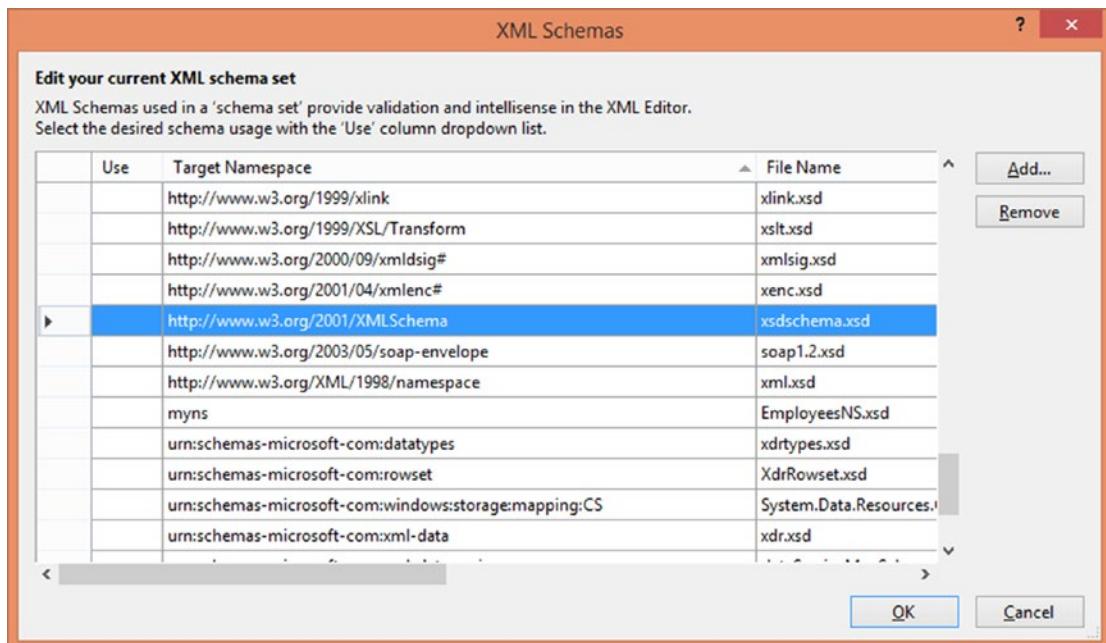


Figure 5-14. Schema set of Visual Studio

You can add or remove schemas from the cache by clicking the Add or Remove buttons, respectively. Once you've added a particular schema, you can use it while writing an XML document by selecting the Use This Schema option of the Schema Set dialog (see Figure 5-15).

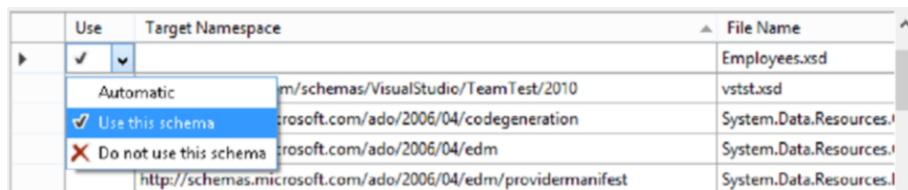


Figure 5-15. Using a schema from the schema set

Using XmlReader to Validate XML Documents

The `XmlReader` class provides you with a way to validate XML documents by using its `Create()` method, which accepts the URL of the XML document and an instance of the `XmlReaderSettings` class. The `XmlReaderSettings` class configures the `XmlReader` class and can be used to indicate your intention of validating XML documents. You can also wire up an event handler to receive notification about validation errors. The `XmlReader` instance returned by the `Create()` method can be used to read the XML document in the same way as you learned in Chapter 3.

To illustrate how to use `XmlReader` to validate XML documents, you will develop an application like the one shown in Figure 5-16.

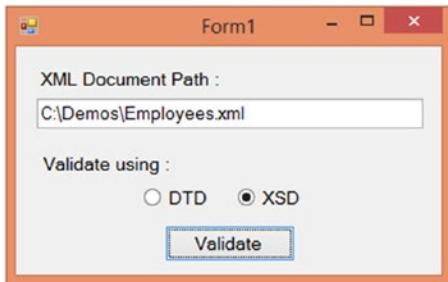


Figure 5-16. Application for validating an XML document by using the `XmlReader` class

The application consists of a text box for accepting the XML document filename. It is assumed that this XML document has either an external DTD or an external XML Schema (XSD) attached to it (as discussed in the preceding sections). The radio buttons indicate whether you are validating against a DTD or XSD. Clicking the Validate button validates the document. Any errors encountered during the validation process are indicated via a message box. Listing 5-15 shows the complete code of the application.

Listing 5-15. Validating an XML Document by Using `XmlReader`

```
private void button1_Click(object sender, EventArgs e)
{
    XmlReaderSettings settings = new XmlReaderSettings();
    settings.XmlResolver = new XmlUrlResolver();

    if (radioButton1.Checked)
    {
        settings.DtdProcessing = DtdProcessing.Parse;
        settings.ValidationType = ValidationTypeDTD;
    }
    else
    {
        settings.ValidationFlags = XmlSchemaValidationFlags.ProcessSchemaLocation;
        settings.ValidationType = ValidationType.Schema;
    }
    settings.ValidationEventHandler += new ValidationEventHandler(OnValidationError);
    XmlReader reader = XmlReader.Create(textBox1.Text, settings);

    while (reader.Read())
    {
        //you can put code here
        //that reads and processes
        //the document
    }

    reader.Close();
    MessageBox.Show("Validation over");
}
```

The code begins by creating an `XmlReaderSettings` object. The `XmlResolver` property of the `XmlReaderSettings` is set to a new `XmlUrlResolver` object so that external DTD or XSD can be located during validation.

If the XML document is to be validated against a DTD (as indicated by the radio buttons), the `DtdProcessing` property of the `XmlReaderSettings` class is set to `DtdProcessing.Parse`. The `DtdProcessing` property decides whether validation against a DTD is allowed. By default, this property is `Prohibit`.

If the document is to be validated against an XML Schema (XSD), the `ValidationFlags` property is set to `ProcessSchemaLocation` (`XmlSchemaValidationFlags` enumeration) so that `XmlResolver` and `XmlReaderSettings` can process the schema locations.

The `ValidationType` property indicates whether `XmlReader` should perform validation and whether to use a DTD or a schema. The `ValidationType` property is an enumeration of type `ValidationType` and has five possible values, as listed in Table 5-3.

Table 5-3. Possible Values of `ValidationType`

Value	Description
None	No validation will be performed. This is the default.
Auto	Automatically decides whether to validate against a DTD or schema by observing the XML document.
DTD	Validation will be performed against a DTD.
Schema	Validation will be performed against an XML Schema (XSD).
XDR	Validation will be performed against an XDR schema.

To trap the validation errors, the `XmlReaderSettings` class raises a `ValidationEventHandler` event. This event is raised only when the `ValidationType` property is other than `None`. The signature of the event-handler function (`OnValidationError()` in our example) must match the one shown here:

```
void OnValidationError(object sender, ValidationEventArgs e)
{
    MessageBox.Show(e.Message);
}
```

The event handler receives a `ValidationEventArgs` object as an event argument, which allows you to examine the underlying exception. You can get the descriptive error message by using the `Message` property as we do in our example. In this case, we simply display a message box with the validation error message.

The code from Listing 5-15 then creates an instance of the `XmlReader` class by calling its `Create()` static method. The URL or path of the XML document and the instance of `XmlReaderSettings` are the arguments. A `while` loop then reads the XML document. If any validation error is detected during this reading operation, the `ValidationEventHandler` event is raised. We could have placed code to read the element and attribute values inside the `while` loop if required (refer to Chapter 3 for information about reading XML documents by using the `XmlReader` class). Finally, the reader is closed.

To test the preceding code, you need to run the application and supply the full path and filenames of an XML document and select from the DTD or XSD radio buttons. You can use the same `Employees.xml` file that we have used throughout this chapter. We also created a DTD and an XML Schema for `Employees.xml` previously. After you click the `Validate` button, the `XmlReader` will attempt to validate the XML document and notify you of any validation errors. Figure 5-17 shows a message box generated after deliberately removing the required attribute—`employeeid`.

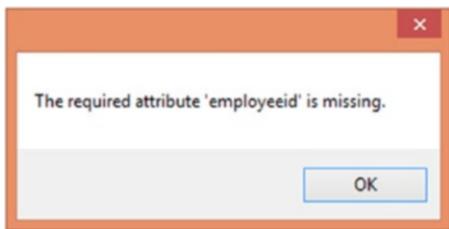


Figure 5-17. Detecting a validation error

Using XmlDocument to Validate XML Documents

You are not limited to the `XmlReader` approach to validate your XML documents; you can also use `XmlDocument` to validate them. This is useful when you are modifying documents and want to ensure that the new data is consistent with the underlying schema or DTD. The `XmlDocument` class allows you to validate XML documents in two ways:

- You can validate the document while it is being loaded by the `XmlDocument` class.
- You can validate the document explicitly when you perform any modification on it such as adding or removing nodes.

In the following example, you will learn how both of the preceding approaches can be used. We will modify the same example that we developed in the “Modifying XML Documents” section of Chapter 2. Figure 5-18 shows the user interface of the application.

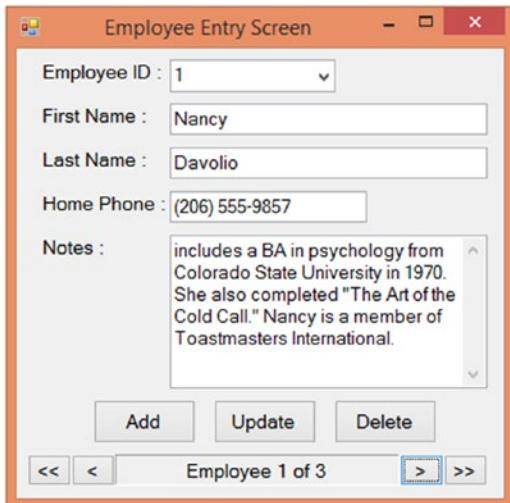


Figure 5-18. Application for validating XML documents by using `XmlDocument`

Because we have already dissected the complete code in Chapter 2, I do not discuss it again here. I discuss only the modifications that are necessary to validate XML documents.

Previously in this section, it was mentioned that `XmlDocument` allows you to validate XML documents when they are being loaded. This is accomplished by passing a validating reader to the `Load()` method of the `XmlDocument` class. Listing 5-16 shows the modified version of the `Form_Load` event handler.

Listing 5-16. Validating an XML Document When It Is Being Loaded

```
private void Form1_Load(object sender, EventArgs e)
{
    XmlReaderSettings settings = new XmlReaderSettings();
    settings.XmlResolver = new XmlUrlResolver();
    settings.ValidationFlags = XmlSchemaValidationFlags.ProcessSchemaLocation;
    settings.ValidationType = ValidationType.Schema;

    settings.ValidationEventHandler += new
        ValidationEventHandler(OnValidationError);
    XmlReader reader =
        XmlReader.Create($"{Application.StartupPath}\\employees.xml", settings);
    doc.Load(reader);
    reader.Close();

    foreach (XmlNode node in doc.DocumentElement.ChildNodes)
    {
        comboBox1.Items.Add(node.Attributes["employeeid"].Value);
    }
    FillControls();
}
```

Notice the code marked in bold. This code should be familiar to you, because we discussed it in the earlier sections of this chapter. It essentially creates an `XmlReaderSettings` object and configures it to validate `Employees.xml` against `Employees.xsd`. The `ValidationEventHandler` event is handled by the `OnValidationError()` method. The `XmlReaderSettings` object is then passed to the `Create()` method of the `XmlReader` class to get an `XmlReader` object.

The `Load()` method of `XmlDocument` accepts the newly created `XmlReader` object as a parameter, internally iterates through the `XmlReader`, and then validation takes place. If there are any validation errors, the `OnValidationError()` method gets called.

Now comes the tricky part. The `XmlDocument` class allows you to modify the document. Thus a document can be valid when loaded but can become invalid after modification. For example, as per our schema, the telephone number cannot be greater than 20 characters. The user of the form can, however, ignore this restriction, and the loaded document can now have invalid data. This makes it necessary to revalidate the changes made to the document. Fortunately, the `XmlDocument` class provides a method called `Validate()` that does the job. Listing 5-17 shows the use of `Validate()` during the update operation.

Listing 5-17. Validating a Node Explicitly

```
private void button2_Click(object sender, EventArgs e)
{
    XmlNode node =
        doc.SelectSingleNode($"//employee[@employeeid='
{comboBox1.SelectedItem}']");
    if (node != null)
    {
        node.ChildNodes[0].InnerText = textBox1.Text;
```

```
node.ChildNodes[1].InnerText = textBox2.Text;
node.ChildNodes[2].InnerText = textBox3.Text;
XmlCDataSection notes = doc.CreateCDataSection(textBox4.Text);
node.ChildNodes[3].ReplaceChild(notes, node.ChildNodes[3].ChildNodes[0]);
}

doc.Validate(OnValidationError, node);

if (!isError)
{
    doc.Save($"{Application.StartupPath}\\employees.xml");
}
}
```

Note the code marked in bold. The `Validate()` method of `XmlDocument` can validate the entire document or just a node against a previously specified schema or DTD. The `Validate()` method accepts two parameters: the name of a function that matches the `ValidationEventHandler` delegate signature and the `XmlNode` to validate. There is one more overload of `Validate()` that takes just a function matching the `ValidationEventHandler` delegate signature and validates the entire document. The `OnValidationError` function is shown in Listing 5-18.

Listing 5-18. The OnValidationError Function

```
void OnValidationError(object sender, ValidationEventArgs e)
{
    MessageBox.Show(e.Message);
    isError = true;
}
```

The function simply shows the error message in a message box and sets a class-level Boolean variable—`isError`—to true. This variable is checked to decide whether to save the document. To test the application, modify the phone number of any employee to more than 20 characters and click the Update button. You should see a message box similar to the one shown in Figure 5-19.

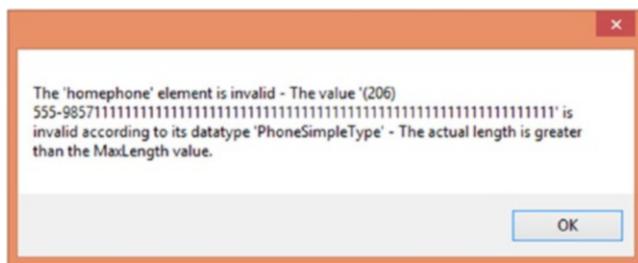


Figure 5-19. Validation error during saving changes

Using XPathNavigator to Validate XML Documents

You might be using `XPathNavigator` to read XML documents and may want to perform validation on those documents. Recollect from Chapter 4 that `XPathNavigator` can be obtained by using the `XmlDocument` or `XPathDocument` classes. The `XPathNavigator` obtained by using `XmlDocument` is editable, whereas that obtained by using `XPathDocument` is read-only. The `XPathNavigator` class by itself does not allow you to validate data, but you can use the underlying `XmlDocument` or `XPathDocument` classes to perform the validation.

We already saw the validation performed by using `XmlDocument`, but just like `XmlDocument`, the `XPathDocument` class allows you to validate XML documents against a schema or DTD during loading. In this case, the constructor of `XPathDocument` can accept a validating `XmlReader` to perform the validation. Because the `XPathNavigator` obtained by using `XPathDocument` is read-only, there is no way to revalidate the XML document after it has been loaded. Listing 5-19 shows how the `XPathNavigator` obtained by using `XPathDocument` can perform the validation.

Listing 5-19. Validating by Using `XPathNavigator`

```
XmlReaderSettings settings = new XmlReaderSettings();
settings.XmlResolver = new XmlUrlResolver();
settings.ValidationFlags = XmlSchemaValidationFlags.ProcessSchemaLocation;
settings.ValidationType = ValidationType.Schema;
settings.ValidationEventHandler += new ValidationEventHandler(OnValidationError);
XmlReader reader = XmlReader.Create(@"C:\Demos\employees.xml", settings);
XPathDocument doc = new XPathDocument(reader);
XPathNavigator navigator = doc.CreateNavigator();
```

The code creates an `XmlReaderSettings` object as before. The `Create()` method of `XmlReader` accepts this `XmlReaderSettings` object and returns an `XmlReader` instance. The `XmlReader` instance is then supplied to the constructor of the `XPathDocument` class. The `CreateNavigator()` method of `XPathDocument` finally creates the `XPathNavigator` that can be used to navigate through the XML document.

Specifying XML Schema via Code

In the preceding examples, the `Employees.xml` file had an associated DTD or XML Schema. Imagine a situation where you have an XML file that doesn't have any schema associated with it, but you want to validate that XML file using some schema.

Suppose you have an application that allows you to export data in XML format. The exported XML file doesn't have any associated schema (inline or external schema file) because it's simply the outcome of the application's export functionality.

Further suppose that a need arises to import these previously exported files into some other application. As a safety measure, you want to ensure that the files being imported adhere to certain schema. But since the exported XML files don't have any schema associated with them, you can't validate them unless you open each file and add schema information into it as discussed earlier.

Luckily, there is a programmatic way to accomplish this task. You can validate such XML files (not having any schema associated with them) by specifying a schema via code. So, rather than the XML file mentioning the schema information, you specify the schema programmatically. To accomplish this task you need to add a schema in the `Schemas` collection of the `XmlReaderSettings`. The `Schemas` collection is an `XmlSchemaSet` object that represents a cache of XSD schemas. You can add a schema to it using its `Add()` method.

To understand how this can be done you will develop a Windows Forms application, as shown in Figure 5-20.

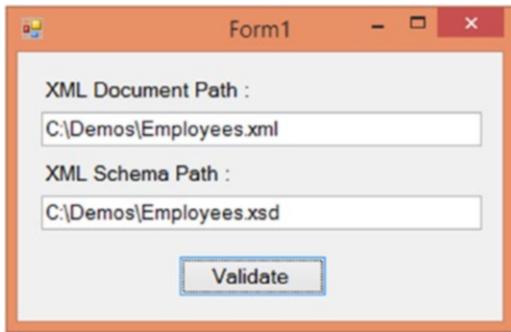


Figure 5-20. Application that attaches a schema via code

The application consists of two text boxes and a button. The first text box is used to specify the path of the XML document, whereas the second text box is used to specify the path of XML Schema (XSD) file. Clicking on the Validate button validates the XML file against the specified XML Schema. Validation errors (if any) are shown using a message box as before.

Listing 5-20 shows the Click event handler of the Validate button.

Listing 5-20. Adding a Schema in XmlSchemaSet

```
private void button1_Click(object sender, EventArgs e)
{
    XmlReaderSettings settings = new XmlReaderSettings();
    settings.ValidationType=ValidationType.Schema;
    settings.Schemas.Add("", textBox2.Text);
    settings.ValidationEventHandler += new ValidationEventHandler(OnValidationError);

    XmlReader reader=XmlReader.Create(textBox1.Text, settings);
    while (reader.Read())
    {
        //you can put code here
        //that reads and processes
        //the document
    }
    reader.Close();
    MessageBox.Show("Validation over");
}
```

Notice the code marked in bold letters. The validationType is set to Schema. This technique of validating XML documents works only for XML Schemas. Further, the code adds an XML Schema to the Schemas collection of the XmlReaderSettings. This way the XML Schema specified in textBox2 is made available to validate the XML document specified in textBox1.

The remainder of the code should be familiar to you, as it has been discussed along with the earlier examples. ");

In order to test this application, remove the schema information from the Employees.xml file and then run the application. Specify the path of the Employees.xml file and the path of Employees.xsd schema file in the respective text boxes. Clicking on the Validate button will validate the XML document. Figure 5-21 shows a sample error message when the employeeid attribute was deliberately removed from the first <employee> element.

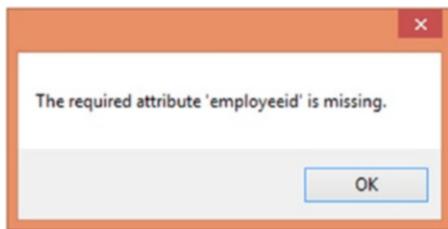


Figure 5-21. Document validated against schema added programmatically

Summary

This chapter introduced you to DTDs and schemas. You learned how to create a DTD and an XML Schema. You also learned to use Visual Studio tools for creating schemas. The .NET Framework's Schema Object Model (SOM) is an extensive collection of objects that allows you to create schemas programmatically. You learned some of the important and commonly used classes from the SOM hierarchy.

Creating a schema or DTD is just half of the story. The other half involves actually validating your XML documents against the specified schema or DTD. To validate an XML document against a schema or DTD, you can use several approaches—that is, with the `XmlReader`, `XmlDocument`, and `XPathNavigator` classes. All the approaches essentially rely on two classes: `XmlReaderSettings` and `XmlReader`. The former class configures the `XmlReader` to perform validation. It also attaches an event handler for handling validation events. The latter class actually reads the document and notifies you of validation errors.

CHAPTER 6



Transforming XML with XSLT

In the previous chapters, we dealt with XML documents and their manipulation. Our interaction with XML documents was limited to reading, writing, querying, and validating them with the help of .NET Framework classes. No doubt these operations are widely needed in real-world XML applications. However, often you also need to transform XML data from one representation to another. For example, you may need to convert XML data into HTML so that it can be displayed in the browser. So, how do we accomplish such a transformation? This is where Extensible Style Sheet Language Transformations (XSLT) comes into the picture.

This chapter covers details of XSLT processing using the .NET Framework classes. Specifically, you will learn the following:

- What XSLT is
- The `XslCompiledTransform` class that is the .NET Framework's XSLT processor
- How to transform XML documents by using `XslCompiledTransform`
- How to use XSLT extension objects
- How to pass parameters to XSLT style sheets
- How to emit script in XSLT style sheets

Overview of XSLT

XML markup often needs to be transformed before it can be put to any use. To cater to this requirement, the W3C introduced Extensible Style Sheet Language (XSL)—a standard for representing style sheets for XML documents. XSL was intended to act along the same lines as Cascading Style Sheets (CSS), which are used to style HTML pages. However, over a period of time, the W3C realized the complexity involved in transforming XML documents, and the overall XSL standards were separated into XSLT, XPath, and XSL-FO. Out of these three main subdivisions, XSLT is intended for transforming XML documents.

Note The XPath standard allows you to query and navigate XML documents; Chapter 4 covered XPath. XSL Formatting Objects (XSL-FO) is intended to format XML documents and is beyond the scope of this book.

XSLT consists of elements and functions that together allow you to transform XML documents. To understand how XSLT elements and functions are used, you will see a simple example.

Suppose that you have an XML document as shown in Listing 6-1. As you can see, it is the same `Employees.xml` file that we have been using for all of our examples.

Listing 6-1. Sample XML Document (Employees.xml)

```
<?xml version="1.0" encoding="utf-8" ?>
<!-- This is list of employees -->
<employees>
    <employee employeeid="1">
        <firstname>Nancy</firstname>
        <lastname>Davolio</lastname>
        <homephone>(206) 555-9857</homephone>
        <notes>
            <![CDATA[Education includes a BA in psychology from Colorado State University in 1970.
She also completed "The Art of the Cold Call." Nancy is a member of Toastmasters International.]]>
        </notes>
    </employee>
    <employee employeeid="2">
        <firstname>Andrew</firstname>
        <lastname>Fuller</lastname>
        <homephone>(206) 555-9482</homephone>
        <notes>
            <![CDATA[Andrew received his BTS commercial in 1974 and a Ph.D. in international marketing
from the University of Dallas in 1981. He is fluent in French and Italian and reads
German. He joined the company as a sales representative, was promoted to sales manager
in January 1992 and to vice president of sales in March 1993. Andrew is a member of the
Sales Management Roundtable, the Seattle Chamber of Commerce, and the Pacific Rim Importers
Association.]]>
        </notes>
    </employee>
    <employee employeeid="3">
        <firstname>Janet</firstname>
        <lastname>Leverling</lastname>
        <homephone>(206) 555-3412</homephone>
        <notes>
            <![CDATA[Janet has a BS degree in chemistry from Boston College (1984).
She has also completed a certificate program in food retailing management.
Janet was hired as a sales associate in 1991 and promoted to sales representative in
February 1992.]]>
        </notes>
    </employee>
</employees>
```

Now further assume that you want to display this XML file in a web browser, as shown in Figure 6-1.

Employee ID	First Name	Last Name	Home Phone	Notes
1	Nancy	Davolio	(206) 555-9857	Education includes a BA in psychology from Colorado State University in 1970. She also completed "The Art of the Cold Call." Nancy is a member of Toastmasters International.
2	Andrew	Fuller	(206) 555-9482	Andrew received his BTS commercial in 1974 and a Ph.D. in international marketing from the University of Dallas in 1981. He is fluent in French and Italian and reads German. He joined the company as a sales representative, was promoted to sales manager in January 1992 and to vice president of sales in March 1993. Andrew is a member of the Sales Management Roundtable, the Seattle Chamber of Commerce, and the Pacific Rim Importers Association.
3	Janet	Leverling	(206) 555-3412	Janet has a BS degree in chemistry from Boston College (1984). She has also completed a certificate program in food retailing management. Janet was hired as a sales associate in 1991 and promoted to sales representative in February 1992.

Figure 6-1. XML document converted to an HTML table

This means you want to convert XML markup into HTML markup. This transformation is achieved by XSLT. Let's see how.

Listing 6-2 shows Employees.xslt—an XSLT style sheet that will be applied to Employees.xml.

Listing 6-2. XSLT for Transforming Employees.xml into an HTML Table

```
<?xml version="1.0" encoding="UTF-8" ?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
  <xsl:template match="/">
    <html>
      <body>
        <h1>Employee Listing</h1>
        <table border="1">
          <tr>
            <th>Employee ID</th>
            <th>First Name</th>
            <th>Last Name</th>
            <th>Home Phone</th>
            <th>Notes</th>
          </tr>
          <xsl:for-each select="employees/employee">
            <tr>
              <td>
                <xsl:value-of select="@employeeid"/>
              </td>
```

```

<td>
  <xsl:value-of select="firstname"/>
</td>
<td>
  <xsl:value-of select="lastname"/>
</td>
<td>
  <xsl:value-of select="homephone"/>
</td>
<td>
  <xsl:value-of select="notes"/>
</td>
</tr>
</xsl:for-each>
</table>
</body>
</html>
</xsl:template>
</xsl:stylesheet>
```

An XSLT file is an XML document in itself, as indicated by the XML processing instruction at the top. The root element of any XSLT style sheet must be `<xsl:stylesheet>`. An XSLT style sheet consists of one or more templates, which are marked with the `<xsl:template>` element. Each template works on one or more elements from the XML file as indicated by the `match` attribute. The forward slash (/) indicates the root element. The `match` attribute can take any valid XPath expression.

Inside the outermost `<xsl:template>` element, the markup outputs an HTML table with four columns: Employee ID, First Name, Last Name, and Notes. We want to pick up every `<employee>` element from the document and extract its attribute and subelement values. The `<xsl:for-each>` element works like a for each loop in any programming language and selects a node set based on the criteria specified in the `select` attribute. In our example, because we want to work with `<employee>` elements, the `select` attribute is set to `employees/employee`. The `select` attribute of `<xsl:for-each>` can take any valid XPath expression.

Inside the `<xsl:for-each>` construct, the values of attributes and elements are retrieved by using the `<xsl:value-of>` element. The `select` attribute of `<xsl:value-of>` must be any valid XPath expression that returns the value to be outputted. Note the use of `@employeeid` to retrieve the value of the `employeeid` attribute. Thus the `employeeid` attribute and the values of the four sub-elements (`<firstname>`, `<lastname>`, `<homephone>`, and `<notes>`) are outputted in the cells of the HTML table.

The same process is repeated for all the employees in the `Employees.xml` file.

Now that you are familiar with the XSLT style sheet, it's time to attach the style sheet to the XML document. To do so, you must add the markup shown in Listing 6-3 to the `Employees.xml` file.

Listing 6-3. Attaching an XSLT Style Sheet to an XML Document

```

<?xml version="1.0" encoding="utf-8" ?>
<?xml-stylesheet type="text/xsl" href="Employees.xslt"?>
<!-- This is list of employees -->
<employees>
  <employee employeeid="1">
    <firstname>Nancy</firstname>
  ...
...
```

Notice the use of the <?xml-stylesheet?> processing instruction. This processing instruction indicates that the type of style sheet being applied is XSL, and it is located at the URL specified by the href attribute. After you attach the style sheet to the XML document, you can view the XML file in the browser, and you should see output similar to Figure 6-1.

In the following sections, you will learn a few more constructs of XSLT.

Applying Templates Using <xsl:apply-templates>

The <xsl:apply-templates> element applies templates to the elements specified by its select attribute. To illustrate the use of <xsl:apply-templates>, we will create an XSLT style sheet that renders the XML markup from Employees.xml, as shown in Figure 6-2.

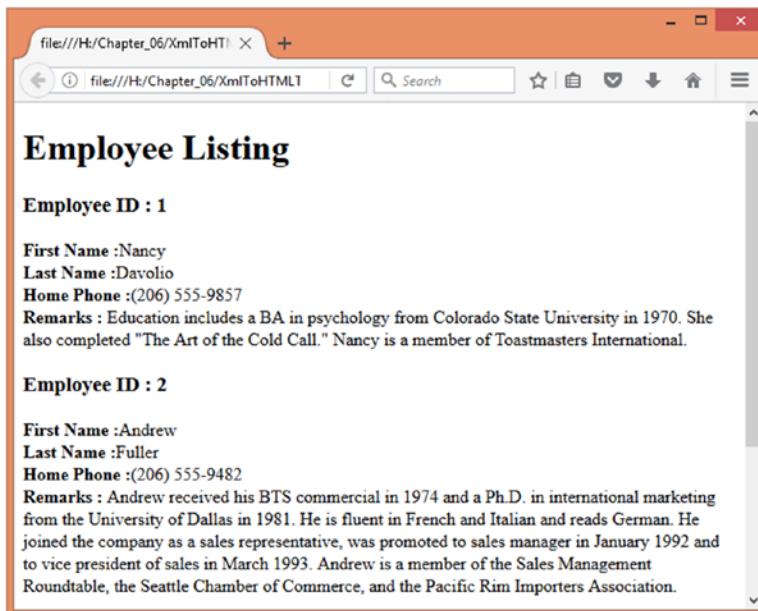


Figure 6-2. Rendering Employees.xml by applying templates

The corresponding style sheet is shown in Listing 6-4.

Listing 6-4. Using <xsl:apply-templates>

```
<?xml version="1.0" encoding="UTF-8" ?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
  <xsl:template match="/">
    <html>
      <body>
        <h1>Employee Listing</h1>
        <xsl:apply-templates/>
      </body>
    </html>
  </xsl:template>
```

```

<xsl:template match="employee">
  <div>
    <h3>Employee ID :
    <xsl:value-of select="@employeeid"/>
  </h3>
    <xsl:apply-templates select="firstname"/>
    <xsl:apply-templates select="lastname"/>
    <xsl:apply-templates select="homephone"/>
    <xsl:apply-templates select="notes"/>
  </div>
</xsl:template>

<xsl:template match="firstname">
  <b>First Name :</b><xsl:value-of select="."/>
  <br />
</xsl:template>

<xsl:template match="lastname">
  <b>Last Name :</b>
  <xsl:value-of select="."/>
  <br />
</xsl:template>

<xsl:template match="homephone">
  <b>Home Phone :</b>
  <xsl:value-of select="."/>
  <br />
</xsl:template>

<xsl:template match="notes">
  <b>Remarks :</b>
  <xsl:value-of select="."/>
  <br />
</xsl:template>

</xsl:stylesheet>

```

This time the topmost `<xsl:template>` element includes an `<xsl:apply-templates>` element. If the `<xsl:apply-templates>` element is used without the `select` attribute, `<xsl:apply-templates>` applies matching templates to all sub-elements. Then, the XSLT declares five templates for the `<employee>`, `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>` elements, respectively.

The template for the `<employee>` element actually decides the order in which the remaining templates will be applied. This is done by specifying the `select` attribute in the `<xsl:apply-templates>` element. The `select` attribute can contain any valid XPath expression.

Branching Using `<xsl:if>`

The XSLT standard provides the `<xsl:if>` element that is equivalent to the `if` statement provided by many programming languages. Suppose that you want to display details only where the first name is *Nancy*. You can achieve this by using `<xsl:if>`, as shown in Listing 6-5.

Listing 6-5. Using `<xsl:if>`

```

<?xml version="1.0" encoding="UTF-8" ?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
  <xsl:template match="/">
    <html>
      <body>
        <h1>Employee Listing</h1>
        <table border="1">
          <tr>
            <th>Employee ID</th>
            <th>First Name</th>
            <th>Last Name</th>
            <th>Home Phone</th>
            <th>Notes</th>
          </tr>
          <xsl:for-each select="employees/employee">>
            <xsl:if test="firstname[text()='Nancy']">
              <tr>
                <td>
                  <xsl:value-of select="@employeeid"/>
                </td>
                <td>
                  <xsl:value-of select="firstname"/>
                </td>
                <td>
                  <xsl:value-of select="lastname"/>
                </td>
                <td>
                  <xsl:value-of select="homephone"/>
                </td>
                <td>
                  <xsl:value-of select="notes"/>
                </td>
              </tr>
            </xsl:if>
          </xsl:for-each>
        </table>
      </body>
    </html>
  </xsl:template>
</xsl:stylesheet>>

```

This is the same style sheet that we used in our first example, but this time, it includes the `<xsl:if>` construct. The `test` attribute of `<xsl:if>` tests for a specific condition. The condition in our example checks whether the value of the `<firstname>` element (`text()`) is Nancy. If it is Nancy, the details are outputted in the resultant HTML table. Figure 6-3 shows a sample view of the `Employees.xml` file after applying the preceding style sheet.

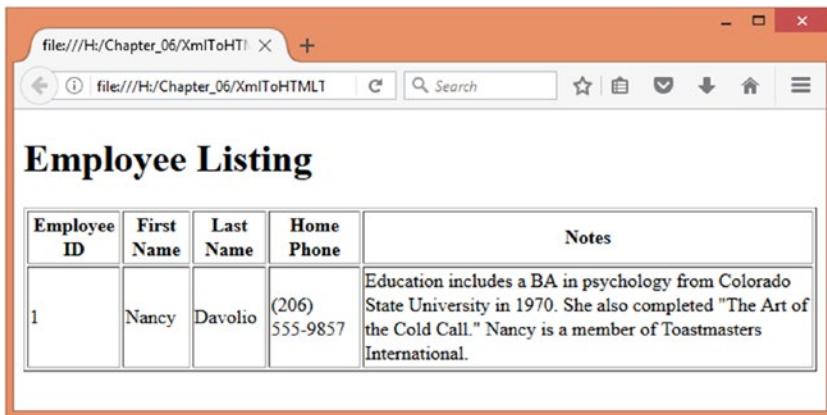


Figure 6-3. Output after using `<xsl:if>`

Branching Using `<xsl:choose>` and `<xsl:when>`

The `<xsl:choose>` and `<xsl:when>` elements are equivalent to the `switch` statement used by programming languages. Using our example file, suppose that you want to display an additional column called Qualification in the resultant HTML table. You want to search the notes about an employee for certain qualifications and accordingly want to display them in this additional column. Listing 6-6 shows the style sheet that accomplishes this task.

Listing 6-6. Using `<xsl:choose>` and `<xsl:when>`

```

<?xml version="1.0" encoding="UTF-8" ?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
<xsl:template match="/">
<html>
<body>
<h1>Employee Listing</h1>
<table border="1">
<tr>
<th>Employee ID</th>
<th>First Name</th>
<th>Last Name</th>
<th>Home Phone</th>
<th>Notes</th>
<th>Qualification</th>
</tr>
<xsl:for-each select="employees/employee">
<tr>
<td>
<xsl:value-of select="@employeeid"/>
</td>
<td>
<xsl:value-of select="firstname"/>
</td>

```

```

<td>
  <xsl:value-of select="lastname"/>
</td>
<td>
  <xsl:value-of select="homephone"/>
</td>
<td>
  <xsl:value-of select="notes"/>
</td>
<td>
<xsl:choose>
  <xsl:when test="notes[contains(., 'BA')]">
    BA (Arts)
  </xsl:when>
  <xsl:when test="notes[contains(., 'BS')]">
    BS (Science)
  </xsl:when>
  <xsl:when test="notes[contains(., 'BTS')]">
    BTS (Other)
  </xsl:when>
  <xsl:otherwise>
    Unknown
  </xsl:otherwise>
</xsl:choose>
</td>
</tr>
</xsl:for-each>
</table>
</body>
</html>
</xsl:template>
</xsl:stylesheet>

```

Notice the markup in bold. The `<xsl:choose>` element starts the switch statement. Each individual `<xsl:when>` element tests a specific condition. In our example, we check whether the `<notes>` element contains BA, BS, or BTS, and accordingly emit the qualification of the employee. If the test fails, the markup from `<xsl:otherwise>` is emitted. Figure 6-4 shows the table with the Qualification column added.

Employee ID	First Name	Last Name	Home Phone	Notes	Qualification
1	Nancy	Davolio	(206) 555-9857	Education includes a BA in psychology from Colorado State University in 1970. She also completed "The Art of the Cold Call." Nancy is a member of Toastmasters International.	BA (Arts)
2	Andrew	Fuller	(206) 555-9482	Andrew received his BTS commercial in 1974 and a Ph.D. in international marketing from the University of Dallas in 1981. He is fluent in French and Italian and reads German. He joined the company as a sales representative, was promoted to sales manager in January 1992 and to vice president of sales in March 1993. Andrew is a member of the Sales Management Roundtable, the Seattle Chamber of Commerce, and the Pacific Rim Importers Association.	BTS (Other)
3	Janet	Leverling	(206) 555-3412	Janet has a BS degree in chemistry from Boston College (1984). She has also completed a certificate program in food retailing management. Janet was hired as a sales associate in 1991 and promoted to sales representative in February 1992.	BS (Science)

Figure 6-4. Qualification column added by using `<xsl:choose>` and `<xsl:when>`

Transforming Elements and Attributes

Up until now, we have transformed XML data into HTML. However, often you may need to transform XML data into another XML representation. For example, a B2B application might be receiving orders electronically in XML format. While receiving such orders, you must ensure that the source XML markup and expected XML markup match. If they do not match, you can apply XSLT transformations to generate the desired markup.

To illustrate how XSLT transformations can convert one XML representation into another, we will transform `Employees.xml` into another XML representation, as shown in Listing 6-7.

Listing 6-7. Required XML Markup from `Employees.xml`

```

<?xml version="1.0" encoding="utf-8"?>
<EMPLOYEES>
  <E1 EMPCODE="1">
    <FNAME>Nancy</FNAME>
    <LNAME>Davolio</LNAME>
    <PHONE>(206) 555-9857</PHONE>
    <REMARKS>
      Education includes a BA in psychology from Colorado State University in 1970. She also completed "The Art of the Cold Call." Nancy is a member of Toastmasters International.
    </REMARKS>
  </E1>
  <E2 EMPCODE="2">
    <FNAME>Andrew</FNAME>
  
```

```

<LNAME>Fuller</LNAME>
<PHONE>(206) 555-9482</PHONE>
<REMARKS>
  Andrew received his BTS commercial in 1974 and a Ph.D. in international
  marketing from the University of Dallas in 1981. He is fluent in French and
  Italian and reads German. He joined the company as a sales representative,
  was promoted to sales manager in January 1992 and to vice president of sales
  in March 1993. Andrew is a member of the Sales Management Roundtable,
  the Seattle Chamber of Commerce, and the Pacific Rim Importers Association.
</REMARKS>
</E2>
<E3 EMPCODE="3">
<FNAME>Janet</FNAME>
<LNAME>Leverling</LNAME>
<PHONE>(206) 555-3412</PHONE>
<REMARKS>
  Janet has a BS degree in chemistry from Boston College (1984).
  She has also completed a certificate program in food retailing management.
  Janet was hired as a sales associate in 1991 and promoted to sales representative in
  February 1992.
</REMARKS>
</E3>
</EMPLOYEES>

```

Notice the several changes made to the XML markup:

- The root node is now `<EMPLOYEES>` and not `<employees>`.
- Each `<employee>` element is replaced with an element of the form `E<employeeid>`—that is, `<E1>`, `<E2>`, and `<E3>`. That means the element name consists of a constant part (`E`) followed by the employee ID.
- The `employeeid` attribute has now become the `EMPCODE` attribute.
- The `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>` elements have now become `<FNAME>`, `<LNAME>`, `<PHONE>`, and `<REMARKS>`, respectively.

The XSLT style sheet that brings about this transformation is shown in Listing 6-8.

Listing 6-8. Transforming Employees.xml

```

<?xml version="1.0" encoding="UTF-8" ?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
  <xsl:template match="/">
    <EMPLOYEES>
      <xsl:apply-templates/>
    </EMPLOYEES>
  </xsl:template>

  <xsl:template match="employee">
    <xsl:element name="E{@employeeid}">
      <xsl:attribute name="EMPCODE">
        <xsl:value-of select="@employeeid"/>
      </xsl:attribute>
    </xsl:element>
  </xsl:template>

```

```

<xsl:apply-templates select="firstname"/>
<xsl:apply-templates select="lastname"/>
<xsl:apply-templates select="homephone"/>
<xsl:apply-templates select="notes"/>
</xsl:element>
</xsl:template>

<xsl:template match="firstname">
<FNAME>
  <xsl:value-of select=". "/>
</FNAME>
</xsl:template>

<xsl:template match="lastname">
<LNAME>
  <xsl:value-of select=". "/>
</LNAME>
</xsl:template>

<xsl:template match="homephone">
<PHONE>
  <xsl:value-of select=". "/>
</PHONE>
</xsl:template>
<xsl:template match="notes">
<REMARKS>
  <xsl:value-of select=". "/>
</REMARKS>
</xsl:template>
</xsl:stylesheet>

```

Notice the code marked in bold. The topmost `<xsl:template>` element now contains the `<EMPLOYEES>` element. The template that matches the `<employee>` element does an interesting job: the `<xsl:element>` element is used to define new elements in the resultant output. You might be wondering why we need this element; after all, you can directly specify new element names (as we do for `<FNAME>`, `<LNAME>`, `<PHONE>`, and `<REMARKS>` later on). Note that we need to create an element name that is E followed by the employee ID. Something like this can be accomplished only by using the `<xsl:element>` element. Observe carefully how the element name has been formed by specifying the dynamic part (employee ID) in curly brackets. Next, the `<xsl:attribute>` element defines the `EMPCODE` attribute. The templates for `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>` are then applied. In each of these templates, the new markup tag is emitted along with the value of the element.

If you open this file in a web browser, you may not see the desired markup because the output is not HTML this time. The Visual Studio IDE provides an easy way to see the resultant output. Open the XML document (`Employees.xml`) in the IDE and apply the latest style sheet to it by using the `xml-stylesheet` processing instruction. Then choose `XML ▶ Start XSLT Debugging` from the menu. Visual Studio will apply the style sheet to the XML document and display the resultant output.

The `XslCompiledTransform` Class

Up until now, we have attached XSLT style sheets to XML documents at design time. However, in many real-world cases, you may need to apply them programmatically. For example, you might be generating the XML data at runtime and want to transform it by using XSLT. The `XslCompiledTransform` class is intended for just such a situation. The `XslCompiledTransform` class resides in the `System.Xml.Xsl` namespace and represents the .NET Framework's XSLT processor. It compiles the XSLT style sheets and performs XSLT transformations.

The `XslCompiledTransform` class can accept XML data to transform it in several forms. Similarly, the output generated by `XslCompiledTransform` can be in various forms. To be specific, the source of transformation can be as follows:

- An object that implements `IXPathNavigator` (for example, `XmlNode` or `XPathDocument`)
- An `XmlReader`
- A URL or path of the XML file

The output of the transformation can be in the form of the following:

- An `XmlWriter` class
- A physical disk file
- A stream (for example, `MemoryStream` or `FileStream`)
- An object of a class inheriting from the `TextWriter` abstract class (for example, `StringWriter` or `StreamWriter`)

Performing Transformations Using `XslCompiledTransform`

In this section, you will learn to use the `XslCompiledTransform` class. You will develop an application like the one shown in Figure 6-5.

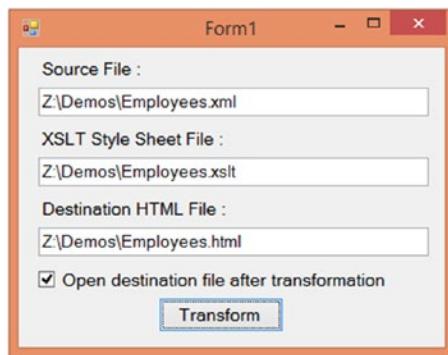


Figure 6-5. Application to apply XSLT transformations

As shown in Figure 6-5, the application consists of three text boxes to accept the source XML filename, the XSLT style sheet filename, and the destination HTML filename, respectively. Clicking the Transform button performs the transformation, and the output of the transformation is stored in a file specified by the Destination File text box. You can also open the destination file after a successful transformation by selecting the check box. Listing 6-9 shows the Click event handler of the Transform button.

Listing 6-9. Using the `XslCompiledTransform` Class

```
private void button1_Click(object sender, EventArgs e)
{
    if(Path.GetExtension(textBox3.Text)!=".htm" &&
       Path.GetExtension(textBox3.Text)!=".html")
    {
        MessageBox.Show("File extension must be .htm or .html");
        return;
    }
XslCompiledTransform xslt = new XslCompiledTransform();
xslt.Load(textBox2.Text);
xslt.Transform(textBox1.Text, textBox3.Text);
if (checkBox1.Checked)
{
    System.Diagnostics.Process.Start(textBox3.Text);
}
}
```

Make sure to import the `System.Xml.Xsl` namespace because the `XslCompiledTransform` class resides in it. Notice the code marked in bold. To start with, the code creates an instance of the `XslCompiledTransform` class. The `Load()` method of `XslCompiledTransform` accepts the path of the XSLT style sheet to be applied and loads it for transformation. However, it is the `Transform()` method that actually performs the transformation by applying the style sheet loaded by using the `Load()` method. There are several overloads of the `Transform()` method; the one that we have used accepts two string parameters. The first parameter is the path of the source XML document, and the second parameter is the path of the destination document. After the transformation, the resultant output is saved in the file specified by the second parameter of the `Transform()` method. Finally, the file is opened with the associated application (typically a web browser for HTML files) by using the `Start()` method of the `Process` class.

To test the application, you can use the `Employees.xml` and `Employees.xslt` files (see Listing 6-2) that we used earlier in this chapter. Note that `Employees.xml` no longer needs to have the `xml-stylesheet` processing instruction. When you supply all the filenames and click the Transform button, you should see the `Employees.html` file generated in the specified folder. The `Employees.html` file will have HTML markup shown in Listing 6-10.

Listing 6-10. Output After Applying the Style Sheet

```
<html>
<body>
<h1>Employee Listing</h1>
<table border="1">
<tr>
<th>Employee ID</th>
<th>First Name</th>
<th>Last Name</th>
```

```

<th>Home Phone</th>
<th>Notes</th>
</tr>
<tr>
<td>1</td>
<td>Nancy</td>
<td>Davolio</td>
<td>(206) 555-9857</td>
<td>
    Education includes a BA in psychology from Colorado State University in 1970.
    She also completed "The Art of the Cold Call." Nancy is a member of Toastmasters
    International.
</td>
</tr>
<tr>
<td>2</td>
<td>Andrew</td>
<td>Fuller</td>
<td>(206) 555-9482</td>
<td>
    Andrew received his BTS commercial in 1974 and a Ph.D. in international marketing
    from the University of Dallas in 1981. He is fluent in French and Italian and
    reads German. He joined the company as a sales representative, was promoted to
    sales manager in January 1992 and to vice president of sales in March 1993. Andrew
    is a member of the Sales Management Roundtable, the Seattle Chamber of Commerce,
    and the Pacific Rim Importers Association.
</td>
</tr>
<tr>
<td>3</td>
<td>Janet</td>
<td>Leverling</td>
<td>(206) 555-3412</td>
<td>
    Janet has a BS degree in chemistry from Boston College (1984). She has also
    completed a certificate program in food retailing management. Janet was hired as a
    sales associate in 1991 and promoted to sales representative in February 1992.
</td>
</tr>
</table>
</body>
</html>

```

As you can see, the source XML markup is transformed into HTML markup as specified in the style sheet.

Note In our example, we converted XML markup into HTML markup. However, you can easily use the `XslCompiledTransform` class to transform source XML into another XML representation.

Passing Arguments to a Transformation

In Listing 6-5, you created a style sheet that transforms details of a single employee, Nancy, by using the `<xsl:if>` element. The problem with our XSLT is that we hard-coded the name *Nancy* in the style sheet. In real-world cases, this name will probably come from a user interface element. Thus, it becomes necessary that the employee's first name be accepted as a parameter in the XSLT rather than a fixed value.

Fortunately, XSLT allows you to declare parameters in your style sheet. These parameters can then be supplied at runtime from your application. A collection of these parameters is represented by the `XsltArgumentList` class, and you can add individual parameters to this collection. To illustrate the use of `XsltArgumentList`, we will develop an application like the one shown in Figure 6-6.

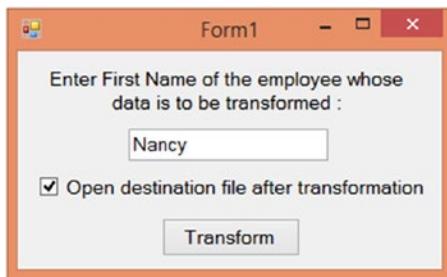


Figure 6-6. Application for passing parameters to the XSLT style sheet

The application consists of a single text box for accepting the first name of the employee. Clicking the Transform button applies the style sheet and stores the resultant output in an HTML file. Our XML file remains the same (`Employees.xml`). However, you need to modify the style sheet from Listing 6-5 as shown in Listing 6-11.

Listing 6-11. XSLT Style Sheet with Parameter

```
<?xml version="1.0" encoding="UTF-8" ?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
  <xsl:param name="firstname"/>
  <xsl:template match="/">
    <html>
      <body>
        <h1>Employee Listing</h1>
        <table border="1">
          <tr>
            <th>Employee ID</th>
            <th>First Name</th>
            <th>Last Name</th>
            <th>Home Phone</th>
            <th>Notes</th>
          </tr>
          <xsl:for-each select="employees/employee">
            <xsl:if test="firstname[text()=$firstname]">
              <tr>
                <td>
                  <xsl:value-of select="@employeeid"/>
                </td>
              </tr>
            </xsl:if>
          </xsl:for-each>
        </table>
      </body>
    </html>
  </xsl:template>
</xsl:stylesheet>
```

```

<td>
    <xsl:value-of select="firstname"/>
</td>
<td>
    <xsl:value-of select="lastname"/>
</td>
<td>
    <xsl:value-of select="homephone"/>
</td>
<td>
    <xsl:value-of select="notes"/>
</td>
</tr>
</xsl:if>
</xsl:for-each>
</table>
</body>
</html>
</xsl:template>
</xsl:stylesheet>
```

Notice the style sheet markup displayed in bold. At the top of the style sheet, we have declared a parameter by using the `<xsl:param>` element. The name attribute of the `<xsl:param>` element indicates the name of the parameter (firstname in our example). To use this parameter further in the XSLT, you prefix it with the dollar symbol (\$). Notice the `firstname` parameter of the `<xsl:if>` element. Listing 6-12 shows the code that passes this parameter value at the time of actual transformation.

Listing 6-12. Using the `XsltArgumentList` Class to Pass XSLT Parameters

```

private void button1_Click(object sender, EventArgs e)
{
    string sourcefile = $"{Application.StartupPath}\\employees.xml";
    string xsltfile = $"{Application.StartupPath}\\employees.xslt";
    string destinationfile = $"{Application.StartupPath}\\employees.html";

    FileStream stream = new FileStream(destinationfile, FileMode.Create);

    XslCompiledTransform xslt = new XslCompiledTransform();
    xslt.Load(xsltfile);
    XsltArgumentList arguments = new XsltArgumentList();
    arguments.AddParam("firstname", "", textBox1.Text);
    xslt.Transform(sourcefile, arguments, stream);
    stream.Close();
    if (checkBox1.Checked)
    {
        System.Diagnostics.Process.Start(destinationfile);
    }
}
```

The code declares three string variables to store the paths of the source XML file, the XSLT style sheet file, and the destination HTML file, respectively. Then the code creates a `FileStream` object for writing to the destination HTML file. This `FileStream` object will be passed to the `Transform()` method later.

A new instance of the `XslCompiledTransform` class is then created, and the `Load()` method loads the XSLT style sheet. Then comes the important part. The code creates an instance of the `XsltArgumentList` class and adds a parameter to it by using its `AddParam()` method, which takes three parameters: the name of the parameter, the namespace if any, and the parameter value. Then, the `Transform()` method of `XslCompiledTransform` is called by passing the `XsltArgumentList` object that we just created. This time, we pass the source filename, the parameter list, and a stream to which the resultant output will be written. In our case, this stream points to the `Employees.html` file. After the transformation is over, the stream is closed, and the newly generated HTML file is shown to the user.

If you run the application and supply Nancy as the parameter value, the resultant HTML file will look like Listing 6-13.

Listing 6-13. Output After Passing the Parameter

```
<html>
  <body>
    <h1>Employee Listing</h1>
    <table border="1">
      <tr>
        <th>Employee ID</th>
        <th>First Name</th>
        <th>Last Name</th>
        <th>Home Phone</th>
        <th>Notes</th>
      </tr>
      <tr>
        <td>1</td>
        <td>Nancy</td>
        <td>Davolio</td>
        <td>(206) 555-9857</td>
        <td>
          Education includes a BA in psychology from Colorado State University in 1970.
          She also completed "The Art of the Cold Call." Nancy is a member of Toastmasters
          International.
        </td>
      </tr>
    </table>
  </body>
</html>
```

As you can see, only one record is transformed, indicating that the output was indeed filtered based on the parameter value.

Using Script Blocks in an XSLT Style Sheet

Though XSLT offers a few programming constructions and built-in functions, it is not a full-fledged programming language in itself. Sometimes, you may need to perform an operation that is beyond the capabilities of XSLT. For example, you may want to connect with a SQL Server database and fetch some data that is used further by the style sheet, or you may need to perform disk IO. To cater to such needs, `XslCompiledTransform` allows you to embed scripts within your XSLT style sheets. After the style sheet is loaded, the embedded code is compiled into Microsoft Intermediate Language (MSIL) and executed at runtime.

Our Employees.xml file stores a subset of information from the Employees table of the Northwind database; it represents only four fields of the actual table: firstname, lastname, homephone, and notes. Let's assume that for some reason you also need the extract the date of birth of each employee at runtime. That means we need to write some ADO.NET code to retrieve the BirthDate column value from the database table. We will do this by embedding a script block in the style sheet. Listing 6-14 shows the complete style sheet.

Listing 6-14. Embedded Script Blocks in the XSLT Style Sheet

```
<?xml version="1.0" encoding="UTF-8" ?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
  xmlns:msxsl="urn:schemas-microsoft-com:xslt"
  xmlns:myscripts="urn:myscripts">
  <msxsl:script language="C#" implements-prefix="myscripts">
    <msxsl:assembly name="System.Data" />
    <msxsl:using namespace="System.Data" />
    <msxsl:using namespace="System.Data.SqlClient" />
    <![CDATA[
      public string GetBirthDate(int employeeid)
      {
        SqlConnection cnn = new SqlConnection(@"data source=.\sqlexpress;initial catalog=northwind;integrated security=true");
        SqlCommand cmd = new SqlCommand();
        cmd.Connection = cnn;
        cmd.CommandText = "SELECT birthdate FROM employees WHERE employeeid=@id";
        SqlParameter pDOB = new SqlParameter("@id",employeeid);
        cmd.Parameters.Add(pDOB);
        cnn.Open();
        object obj = cmd.ExecuteScalar();
        cnn.Close();
        DateTime dob = DateTime.Parse(obj.ToString());
        return dob.ToString("MM/dd/yyyy");
      }
    ]]>
  </msxsl:script>

  <xsl:template match="/">
    <html>
      <body>
        <h1>Employee Listing</h1>
        <table border="1">
          <tr>
            <th>Employee ID</th>
            <th>First Name</th>
            <th>Last Name</th>
            <th>Home Phone</th>
            <th>Birth Date</th>
            <th>Notes</th>
          </tr>
        </xsl:for-each select="employees/employee">
        <tr>
```

```

<td>
    <xsl:value-of select="@employeeid"/>
</td>
<td>
    <xsl:value-of select="firstname"/>
</td>
<td>
    <xsl:value-of select="lastname"/>
</td>
<td>
    <xsl:value-of select="homephone"/>
</td>
<td>
    <b><xsl:value-of select="myscripts:GetBirthDate(@employeeid)" /></b>
</td>
<td>
    <xsl:value-of select="notes"/>
</td>
</tr>
</xsl:for-each>
</table>
</body>
</html>
</xsl:template>
</xsl:stylesheet>

```

Notice the markup in bold. The `<xsl:stylesheet>` element now has two more attributes. The `xmlns:msxsl` attribute defines the `msxml` prefix for the `urn:schemas-microsoft-com:xslt` namespace. Similarly, the `xmlns:myscripts` attribute defines a `myscripts` prefix.

The `<msxml:script>` block defines one or more functions that are used in the style sheet. The `language` attribute of the script block indicates the coding language (C# in our example). Your code may need to add a reference to external assemblies, which is done by using the `<msxsl:assembly>` element. The `name` attribute of this tag specifies the name of the assembly, excluding the extension. Similarly, the `<msxml:using>` tag specifies the namespaces to be imported.

The actual function is placed in a CDATA section. In our example, we defined a function called `GetBirthDate()` that accepts the ID of the employee whose date of birth is to be retrieved and returns the birth date in MM/dd/yyyy format. The code of the function connects to the Northwind database, fires a `SELECT` query against the `employees` table, and retrieves the birth date.

Note Make sure to change the database connection string to suit your development environment.

The `GetBirthDate()` function is called later in the style sheet by using the `namespaceprefix: function_name(parameter list)` syntax. The `GetBirthDate()` function expects the employee ID, which is passed by using the `employeeid` attribute (`@employeeid`) as a parameter.

To test our new style sheet, we will develop an application like the one shown in Figure 6-7.

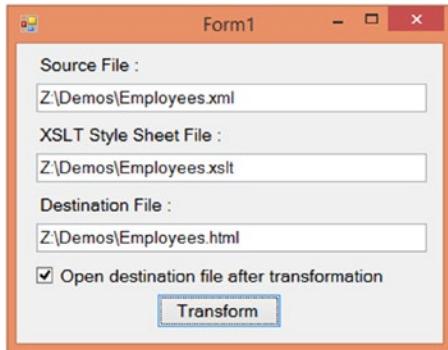


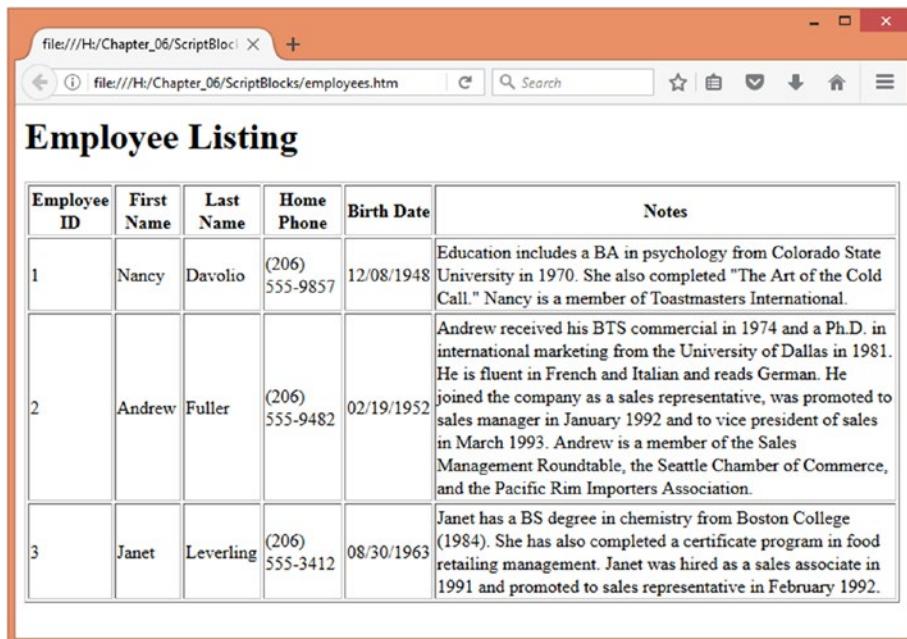
Figure 6-7. Application for testing our embedded function

The application user interface is the same as I discussed earlier (see Figure 6-5). However, the code inside the Transform button is slightly different. Listing 6-15 highlights these differences.

Listing 6-15. Enabling Scripting

```
private void button1_Click(object sender, EventArgs e)
{
    XsltSettings settings = new XsltSettings();
    settings.EnableScript = true;
    XslCompiledTransform xslt = new XslCompiledTransform();
    xslt.Load(textBox2.Text, settings, null);
    xslt.Transform(textBox1.Text, textBox3.Text);
    if (checkBox1.Checked)
    {
        System.Diagnostics.Process.Start(textBox3.Text);
    }
}
```

The `XsltSettings` class specifies the features to support during the transformation. The `EnableScript` property indicates whether to enable embedded script blocks. The `Load()` method of the `XslCompiledTransform` class accepts the `XsltSettings` object as one of its parameters. If you run the application and specify the three paths, you will get output as shown in Figure 6-8.



The screenshot shows a Microsoft Internet Explorer window with the title bar "file:///H:/Chapter_06/ScriptBlocks/employees.htm". The page content is titled "Employee Listing" and displays a table with six columns: Employee ID, First Name, Last Name, Home Phone, Birth Date, and Notes. The table has three rows, each representing an employee with their details and a corresponding note in the Notes column.

Employee ID	First Name	Last Name	Home Phone	Birth Date	Notes
1	Nancy	Davolio	(206) 555-9857	12/08/1948	Education includes a BA in psychology from Colorado State University in 1970. She also completed "The Art of the Cold Call." Nancy is a member of Toastmasters International.
2	Andrew	Fuller	(206) 555-9482	02/19/1952	Andrew received his BTS commercial in 1974 and a Ph.D. in international marketing from the University of Dallas in 1981. He is fluent in French and Italian and reads German. He joined the company as a sales representative, was promoted to sales manager in January 1992 and to vice president of sales in March 1993. Andrew is a member of the Sales Management Roundtable, the Seattle Chamber of Commerce, and the Pacific Rim Importers Association.
3	Janet	Leverling	(206) 555-3412	08/30/1963	Janet has a BS degree in chemistry from Boston College (1984). She has also completed a certificate program in food retailing management. Janet was hired as a sales associate in 1991 and promoted to sales representative in February 1992.

Figure 6-8. Output with the Birth Date column added

Using Extension Objects

Embedding scripts in the style sheet does indeed provide a handy way to perform operations that are beyond the capabilities of XSLT. However, it doesn't provide a good mechanism for reusing your code. What if you want to use the same function elsewhere in the application or in other style sheets? This is where extension objects come into the picture. Simply put, extension objects are objects external to the style sheet that provide some functionality to the style sheet. Extension objects promote greater code reuse and are more flexible and maintainable than embedded script blocks.

To illustrate the use of extension objects, we will modify our previous example. First, we will put the `GetBirthDate()` function in a separate class called `Employee` rather than embedding it in the style sheet. The newly created `Employee` class should look similar to Listing 6-16.

Listing 6-16. Placing the `GetBirthDate()` Function in a Class

```
class Employee
{
    public string GetBirthDate(int employeeid)
    {
        SqlConnection cnn = new SqlConnection(@"data source=.\sqlexpress;initial catalog=northwind;integrated security=true");
        SqlCommand cmd = new SqlCommand();
        cmd.Connection = cnn;
        cmd.CommandText = "SELECT birthdate FROM employees WHERE employeeid=@id";
        SqlParameter pDOB = new SqlParameter("@id", employeeid);
        cmd.Parameters.Add(pDOB);
        cnn.Open();
```

```

        object obj = cmd.ExecuteScalar();
        cnn.Close();
        DateTime dob = DateTime.Parse(obj.ToString());
        return dob.ToString("MM/dd/yyyy");
    }
}

```

The function by itself is the same one that we used before, but it has been encapsulated in the Employee class. Next, you need to modify the Click event handler of the Transform button to resemble Listing 6-17.

Listing 6-17. Using Extension Objects

```

private void button1_Click(object sender, EventArgs e)
{
    XsltSettings settings = new XsltSettings();
    settings.EnableScript = true;
    XslCompiledTransform xslt = new XslCompiledTransform();
    xslt.Load(textBox2.Text, settings, null);

XsltArgumentList arguments = new XsltArgumentList();
Employee employee = new Employee();
arguments.AddExtensionObject("urn:myscripts", employee);

FileStream stream = new FileStream(textBox3.Text, FileMode.Create);
xslt.Transform(textBox1.Text, arguments, stream);
    stream.Close();
    if (checkBox1.Checked)
    {
        System.Diagnostics.Process.Start(textBox3.Text);
    }
}

```

Notice the code marked in bold. After loading the style sheet using the Load() method as before, it creates an instance of the XsltArgumentList class, which we used when passing parameters to the style sheet. This time, however, the code uses the AddExtensionObject() method of the XsltArgumentList class. This method accepts the namespace URI and an instance of the extension object. In our case, the Employee class instance acts as an extension object. While calling the Transform() method of XslCompiledTransform, the XsltArgumentList object is passed to it. If you run the application now, you should get a result identical to the previous example.

Compiling XSLT Style Sheets

In all the preceding examples, we used XSLT files directly for the purpose of transformation. If you are dealing with many style sheets, you need to keep track of each and every style sheet name during coding. You also need to deploy all the style sheets along with other project files.

Luckily, the .NET Framework comes with a command-line XSLT compiler, xsldc.exe, that can compile one or more XSLT style sheets into an assembly. You can then load the required style sheet into the XslCompiledTransform instance and apply it to your XML documents.

To illustrate the use of the XSLT compiler, let's compile the `Employees.xslt` that we developed earlier in this chapter. Open a Visual Studio command prompt and issue the following command:

```
xsltc /class:MyStyles.Employees Employees.xslt /out:EmployeeStyles.dll
```

The `/class` switch is used to specify the fully qualified name of the resultant class (`MyStyles.Employees` in our example). The name of the XSLT style sheet follows the class name. If you want to compile multiple style sheets, you can specify multiple pairs of class names and style sheet names. The `/out` switch specifies the name of the output assembly. You can add a reference to this assembly in your project.

To consume the assembly that was just created, we will modify the example shown in Figure 6-5. The modified application is shown in Figure 6-9.

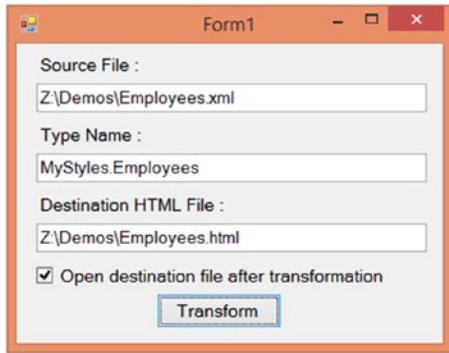


Figure 6-9. Application for testing compiled style sheets

The application now accepts the fully qualified type name of the class that represents the XSLT style sheet instead of the XSLT style sheet file path. The code inside the Click event of the Transform button now changes as shown in Listing 6-18.

Listing 6-18. Loading the Compiled Style Sheet Using the `XslCompiledTransform` Class

```
private void button1_Click(object sender, EventArgs e)
{
    if(Path.GetExtension(textBox3.Text) != ".htm" &&
       Path.GetExtension(textBox3.Text) != ".html")
    {
        MessageBox.Show("File extension must be .htm or .html");
        return;
    }
    XslCompiledTransform xslt = new XslCompiledTransform();
    Assembly a = Assembly.Load("EmployeeStyles");
    Type t = a.GetType(textBox2.Text);
    xslt.Load(t);
    xslt.Transform(textBox1.Text, textBox3.Text);
    if (checkBox1.Checked)
    {
        System.Diagnostics.Process.Start(textBox3.Text);
    }
}
```

Notice the code marked in bold. The code uses the `Load()` method of the `Assembly` class (`System.Reflection` namespace) to load the `EmployeeStyles` assembly we created earlier. Remember that you still need a reference to the `EmployeeStyles` assembly in your project. The code then gets a `Type` instance of the compiled style sheet class. It then passes this `Type` instance to the `Load()` method of the `XslCompiledTransform` class.

Summary

This chapter gave you a detailed understanding of XSLT processing in the .NET Framework. By using XSLT style sheets, XML data can be transformed from one form to another. The `XslCompiledTransform` class represents the .NET Framework's XSLT processor. It allows you to load the style sheets and apply them to source XML. You can also pass parameters while transformation is being carried out, by using the `XsltArgumentList` class. The `XslCompiledTransform` class also allows you to embed script blocks. A better way to use your code is to create extension objects, which are more flexible and maintainable than embedded script blocks.

CHAPTER 7



XML in ADO.NET

ADO.NET is a technology for accessing and manipulating databases. XML has been integrated in several ways in ADO.NET. In this chapter, you are going to see how ADO.NET has harnessed the power of XML in data representation. Specifically, this chapter covers the following:

- An overview of XML integration in ADO.NET
- Working with `SqlDataReader` and XML
- `DataSet` architecture and disconnected data access
- XML integration in `DataSet`
- Creating a typed `DataSet`

Overview of ADO.NET Architecture

ADO.NET provides two ways of working with your data:

- Connected data access
- Disconnected data access

Connected Data Access

In *connected data access*, you establish a connection with the database. Then, as long as you are working with the data, you maintain this live connection. The following are the steps that you typically take when using connected data access:

1. Establish a connection with the database.
2. Open a cursor through the established connection.
3. Iterate through the cursor and work with the data (perform read, modify, and delete operations or even calculations).
4. Update the database, if there are any changes.
5. Close the cursor and the database connection.

The advantage of this model is that you can see changes in the database in real time. However, this approach is not recommended for scalable applications because it can hamper the overall performance and scalability of the system. Also, even though ADO.NET provides cursor-oriented connected data access, it is strictly read-only and forward-only. This incurs fewer overheads and improves performance as compared to updatable cursors.

You will typically use connected data access in the following situations:

- You are developing applications that are online all the time. For example, in a ticket reservation application, it is necessary that you work with the latest data from the database. In such cases, connected data access becomes necessary.
- You want to avoid the overhead of using offline data. When you use queries directly against a database, naturally they bypass any of the intermediate layers that are involved in disconnected data-access techniques. For example, suppose that you want to display a simple employee listing to the end user. This task does not involve any processing as such. Using connected data access in such cases will of course give the best performance.
- You need a cursor model for some reason.

The Connection, Command, and DataReader classes are used for such connected data access. You learn about these classes in later sections.

Disconnected Data Access

Many modern systems need to be distributed and scalable. Consider an example of a distributed application that performs some database-intensive tasks. A typical programming approach is to open a live connection with the database and maintain it as long as the database-related tasks are in progress. This is fine if the number of users is small, but as the user base grows, the available database connections become precious. In such heavily loaded systems, a live connection approach is not recommended. The alternative is to have offline or disconnected access to the data. *Disconnected data access* involves the following steps:

1. Establish a connection with the database.
2. Fetch the data that you require and store it in some offline medium.
3. Close the database connection.
4. Work with the fetched data (perform read, modify, and delete operations or even calculations).
5. Again, open a database connection if you want to update the changes made to the data back to the database.
6. Update the database, if there are any changes.
7. Close the database connection.

As you can see, the database connection is opened only when required. You will typically use disconnected data access in the following situations:

- Your application data can be updated in batches.
- Your application does not need up-to-the minute data from the database.
- You want to pass data across multiple layers of your system.

- You want to pass data from your application to another application.
- Your application data is generated programmatically and is not coming from any data source.

This disconnected data access is provided by a `DataAdapter` and a `DataSet` class. You learn more about these classes in upcoming sections.

ADO.NET Data Providers

To communicate with the data source, you need some kind of layer that will facilitate this communication for you. In the early days, Open Database Connectivity (ODBC) drivers provided such a layer. With the introduction of Object Linking and Embedding Database (OLEDB), OLEDB providers did the same job. With ADO.NET, it is data providers that do it for you by providing managed access to the underlying data source. The data source can be a relational database management system (RDBMS) such as SQL Server or it can be some non-relational entity such as XML documents.

Four chief data providers are available out of the box with ADO.NET:

- SQL Server data provider
- OLEDB data provider
- ODBC data provider
- Oracle data provider

You can also build your own data provider if necessary.

Each ADO.NET data provider consists of a set of classes that are similar in structure (this is achieved through certain common base classes and interfaces) but implement provider specific functionality. This makes the overall object model look almost the same, irrespective of the data provider used. The following sections give you a brief introduction to the various data providers available.

SQL Server Data Provider

The SQL Server data provider is specifically designed for Microsoft SQL Server. It is optimized for SQL Server and uses SQL Server's native data format—tabular data stream (TDS) for communication. As this data provider talks with SQL Server via its native format, there are none of the overheads associated with the OLEDB layer.

OLEDB Data Provider

As the name suggests, the OLEDB data provider is used to communicate with any OLEDB-compliant databases such as SQL Server and Oracle. The OLEDB data provider is actually a wrapper over the corresponding OLEDB service provider and thus introduces a small performance overhead. If your database is OLEDB compliant but does not have its own ADO.NET data provider, this is the data provider for you.

ODBC Data Provider

If you are working with an RDBMS that does not have an ADO.NET data provider or an OLEDB provider (say, dBase), this is the data provider available to you.

Oracle Data Provider

The .NET Framework also includes a data provider developed specifically for Oracle databases.

The Assemblies and Namespaces Involved

Now that you have a brief idea about ADO.NET data providers, let's see the related namespaces. We will focus our attention on only the SQL Server data provider and the OLEDB data provider because they are very commonly used in many business applications. All the data-access classes of these two providers reside in the assembly `System.Data.dll`. There are five major namespaces pertaining to the preceding data providers:

- The `System.Data` namespace provides classes and interfaces that are common to all data providers. For example, the `DataSet` class is the same irrespective of whether it is populated with data from SQL Server or another OLEDB database. This namespace also contains interfaces that are implemented by all the data providers.
- The `System.Data.Common` namespace contains classes shared by all the .NET data providers.
- The `System.Data.OleDb` namespace contains all the classes pertaining to the OLEDB data provider. For example, there are classes such as `OleDbConnection`, `OleDbCommand`, and `OleDbParameter`.
- The `System.Data.SqlClient` namespace contains all the classes related to the SQL Server data provider. For example, there are classes such as `SqlConnection`, `SqlCommand`, and `SqlParameter`. As you will see, the `OleDb` and `SqlParameter` namespaces contain closely matching classes.
- The `System.Data.SqlTypes` namespace provides classes that represent native data types within SQL Server. For example, the `SqlInt32` class represents the SQL Server integer data type. These classes help in preventing loss of precision while converting decimal or numeric data types. They also help in optimizing type conversion between .NET data types and SQL Server data types.

ADO.NET Classes

Now it's time to become familiar with the common classes that play a vital role in database access. This section gives you a basic introduction to the classes so that you can perform common data-access tasks. Note that in the following section when I specify `Connection`, it is shorthand for the `SqlConnection` and `OleDbConnection` classes. The same convention applies to other classes as well.

Connection (`SqlConnection` and `OleDbConnection`)

As the name suggests, the `Connection` classes represent a connection with a database. In order to perform any database operation, you need an open connection with that database. To establish a connection with, say, a SQL Server database, you will need to specify the connection string and then call the `Open()` method of the `SqlConnection` object. Note that after you finish working with the `Connection` object, you should explicitly close it by using the `Close()` method. Otherwise, the object will maintain a live connection with the database.

Command (SqlCommand and OleDbCommand)

ADO.NET Command objects are used to execute SQL queries and stored procedures. You specify the SQL query or stored procedure name by using the `CommandText` property. You can also specify the type of command (SQL statement or stored procedure) by using the `CommandType` property. If your query has some parameters, you can add them to the `Parameters` collection. Before executing the command, you should set its `Connection` property to an open connection object. Command objects can return only read-only and forward-only result sets in the form of a `DataReader`.

Parameter (SqlParameter and OleDbParameter)

Often your queries and stored procedures are parameterized. Using parameters allows you to pass external values to your queries and also avoids the risk of SQL injection attack. Parameters are also better in terms of performance because they avoid frequent parsing of queries. The `Parameter` class represents a parameter of your query or stored procedure.

DataReader (SqlDataReader and OleDbDataReader)

As I mentioned, the `Command` object can return only read-only and forward-only cursors. The cursor is represented by an object called the `DataReader`, which is a firehose cursor that provides an optimized way to loop through your results.

Note Read-only and forward-only cursors are often called *firehose cursors*. They are one of the most efficient ways of transferring data from the server to the client.

To loop through the results, you can use its `Read()` method that advances the record pointer to the next row.

Note that `DataReader` does not have `MoveXxxx()`-style methods that some older data access models used to have. This helps to avoid the common programming mistake of forgetting to call `MoveNext()` in `Do...While` loops. Also, note that for `DataReader`, only one row remains in memory at a time, so `DataReader` can improve the performance and memory footprint of your application significantly as compared to traditional dynamic cursors.

DataAdapter (SqlDataAdapter and OleDbDataAdapter)

In the section about disconnected data access, you learned that ADO.NET offers a way to work with disconnected data via the `DataSet` class. The `DataSet` needs to be populated from the data residing in the data source. Similarly, after you are finished with the data modifications, the data needs to be updated in the underlying data source, and the `DataAdapter` class is designed just for that. Note that the `DataSet` class is the same for any kind of data provider (SQL Server or OLEDB), but `DataAdapter` has separate implementations (`SqlDataAdapter` and `OleDbDataAdapter`). This is because, unlike `DataSet`, which is totally unaware of the underlying data source, `DataAdapter` needs to communicate with the underlying data source.

DataSet

The `DataSet` object is at the heart of ADO.NET disconnected architecture. `DataSet` is somewhat analogous to the `Recordset` object of ADO, but, unlike `Recordset`, `DataSet` always works in a disconnected fashion. Also, `DataSet` can have more than one set of data.

A `DataSet` is represented as an XML document over the network, which makes it a great choice for passing data from one component layer to another. It can also be used to integrate heterogeneous systems.

A `DataSet` can be considered an in-memory representation of a database. Just as a database consists of one or more tables, a `DataSet` consists of one or more `DataTable` objects. Each `DataTable` is a set of `DataRow` objects. Just like a database, `DataTable` objects can have relations and constraints. Also, they need not always be populated from the database but can be created and populated programmatically also.

XML and Connected Data Access

In the preceding sections, you saw that the `SqlCommand` object is used to execute SQL commands and stored procedures against a database. To execute `SELECT` queries and retrieve the results as XML data, you need to use the `ExecuteXmlReader()` method of the `SqlCommand` object. This method executes the `SELECT` query or stored procedure and returns the results in the form of an `XmlReader` object. You can then navigate through and access values from the `XmlReader`, as you learned in Chapter 3.

Using the `ExecuteXmlReader()` Method

When you use the `ExecuteXmlReader()` method of `SqlCommand`, the `SELECT` query must have the `FOR XML` clause specified in it. You will learn about the `FOR XML` clause in detail in Chapter 11. For now it is sufficient to know that this clause ensures that an XML representation of the result set is returned and it must be present.

To see how `ExecuteXmlReader()` works, you will develop an application like the one shown in Figure 7-1.

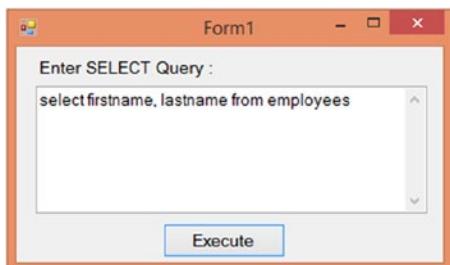


Figure 7-1. Application for retrieving SQL Server data in XML format

As you can see, the application consists of a text box for entering `SELECT` queries. The `Execute` button allows you to execute the query. The XML results returned from the query are displayed in a browser window.

Before you write the code for the `Click` event handler of the `Execute` button, make sure to include the namespaces as shown in Listing 7-1.

Listing 7-1. Importing Relevant Namespaces

```
using System.Data;
using System.Data.SqlClient;
using System.Xml;
using System.IO;
using System.Diagnostics;
```

The Click event handler of the Execute button contains the code shown in Listing 7-2.

Listing 7-2. Using the ExecuteXmlReader() Method

```
private void button1_Click(object sender, EventArgs e)
{
    SqlConnection cnn = new SqlConnection(@"data source=.\sqlexpress;initial catalog=northwind;integrated security=true");

    SqlCommand cmd = new SqlCommand();
    cmd.Connection = cnn;
    cmd.CommandType = CommandType.Text;
    cmd.CommandText = $"{textBox1.Text} FOR XML AUTO";
    cnn.Open();
    XmlReader reader=cmd.ExecuteXmlReader();
    StreamWriter writer= File.CreateText($"{Application.StartupPath}\\temp.xml");
    writer.Write("<root>");

    while (reader.Read())
    {
        writer.Write(reader.ReadOuterXml());
    }

    writer.Write("</root>");
    writer.Close();
    reader.Close();
    cnn.Close();
    Process.Start($"{Application.StartupPath}\\temp.xml");
}
```

The code creates an instance of the `SqlConnection` class by passing the database connection string in the constructor.

Note Throughout this chapter, it is assumed that you have SQL Server (the Express edition is sufficient) installed on your machine. It is also assumed that you have the Northwind sample database of SQL Server. You can download the necessary scripts from Microsoft's web site. Also, make sure to change the database connection string according to your setup.

Then the code creates a `SqlCommand` object and sets three important properties: `Connection`, `CommandType`, and `CommandText`. The `Connection` property specifies the `SqlConnection` instance that is to be used for firing queries. The `CommandType` property is an enumeration of type `CommandType` and indicates the type of command being executed. In our example, it is a plain SQL statement and hence set to `CommandType.Text`. The `CommandText` property specifies the SQL query or name of the stored procedure to be executed. In our example, the query is being supplied via the text box. While assigning the `CommandText` property, the `FOR XML AUTO` clause is appended to the original query. This clause indicates that the results are returned as a sequence of elements, where the element name is the same as the table name, attribute names are the same as column names, and attribute values are the same as column values. The connection is then established by using the `Open()` method of the `SqlConnection` class.

The query is executed against the database by using the `ExecuteXmlReader()` method, which, as you know, returns an instance of `XmlReader` that points to the result set. In our example, the code creates a physical disk file named `temp.xml`, iterates through the `XmlReader` by using its `Read()` method, and writes the XML data to the file. Notice the use of the `ReadOuterXml()` method to retrieve the XML data. Also, note that the XML data returned by `ExecuteXmlReader()` is in the form of elements and doesn't have a root node as such, so the code adds a `<root>` element to enclose all the returned data.

After the writing of XML data is done, the `StreamWriter`, `XmlReader`, and `SqlConnection` are closed by using the `Close()` method of the respective classes. The `Process` class (residing in the `System.Diagnostics` namespace) opens the `temp.xml` file in a new browser window.

If you run the application and supply a `SELECT` query, you should see the output shown in Figure 7-2.

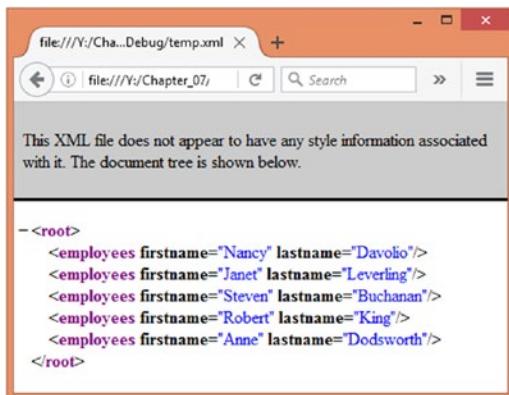


Figure 7-2. XML data returned by the `ExecuteXmlReader()` method

Figure 7-2 shows the output for the following query:

```
SELECT firstname, lastname FROM employees
```

As you can see, the element name is the same as the table name, and columns appear as attributes.

XML and Disconnected Data Access

In the preceding section, you learned the connected way of working by using ADO.NET and `XmlReader`. However, for building scalable applications, connected data access poses problems of its own. In such circumstances, disconnected data access is strongly preferred. In fact, disconnected data access is one of the most important features of ADO.NET.

Two classes—`DataSet` and `SqlDataAdapter`—together provide a way to work with database data in disconnected mode. The `DataSet` object is a totally disconnected one and can even be created manually. The `SqlDataAdapter` class fills the `DataSet` with data from a database and later propagates the changes made to the `DataSet` back to the database. In the next sections, you learn the architecture of `DataSet` and `DataAdapter`, and how to work with them.

Understanding `DataSet`

`DataSet` is an object for storing results of your queries offline for further processing and can be viewed as an in-memory representation of a database. `DataSet` consists of one or more `DataTable` objects, which in turn consist of a collection of `DataRow` objects. Figure 7-3 gives you a complete picture of the internals of `DataSet`.

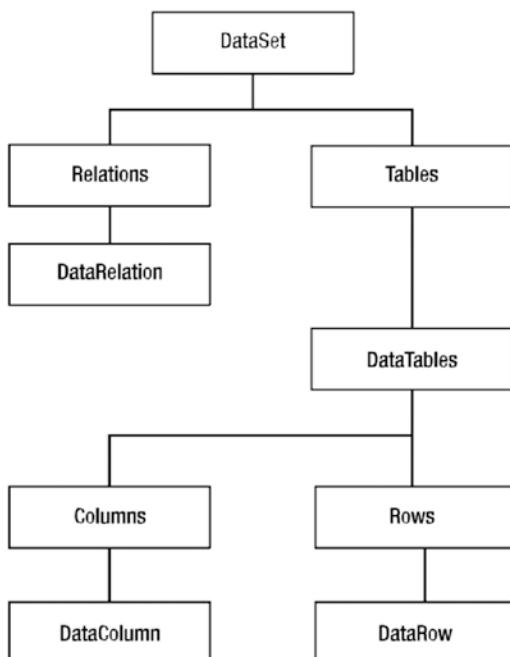


Figure 7-3. *DataSet* architecture

As you can see, `DataSet` has two primary collections:

- The `Tables` collection is exposed by the `Tables` property and consists of a `DataTableCollection` object that can have zero or more `DataTable` objects. Each `DataTable` represents a set of data from the underlying data source.
- The `Relations` collection is exposed as the `Relations` property and consists of a `DataRelationCollection` object. The `DataRelationCollection` object in turn contains zero or more `DataRelation` objects. Each `DataRelation` object represents the parent-child relationship between two `DataTable` objects.

As stated earlier, `DataTable` is a set of data and consists of rows and columns. The `DataTable` class has the following three important collections:

- The `Columns` collection is exposed as the `Columns` property and is an instance of the `DataColumnCollection` class. It contains zero or more `DataColumn` objects. Each `DataColumn` object represents a column or field of the `DataTable`, just like a database column. These columns define the structure of a `DataTable`.
- The `Rows` collection is exposed as the `Rows` property and is an instance of the `DataRowCollection` class. It contains zero or more `DataRow` objects. Each `DataRow` is similar to a database record and contains the actual data of the `DataTable`.
- Just like a database table, a `DataTable` can also have constraints, such as unique key constraints and foreign key constraints. The `Constraints` collection is exposed as the `Constraints` property and is an instance of the `ConstraintCollection` class. It can contain zero or more instances of the `UniqueConstraint` or `ForeignKeyConstraint` classes.

In addition to the preceding classes, there is a special object called `DataView` that is based on a `DataTable`. As the name suggests, `DataView` is used to present different views of data by sorting and filtering data from the `DataTable`. Note that `DataView` does not have independent existence and is always based on a `DataTable`.

Generally, you will populate your `DataSet` with the data from a data source such as a SQL Server database. However, `DataSet` is fully disconnected. Most of the objects of `DataSet` explained earlier can be created independently without any interaction with any data source. This means you can programmatically create your `DataSet` without even connecting with any data source. For example, you may want to import a comma-separated list of string data into a database table. In such cases, you can create `DataSet` and `DataTable` objects programmatically and populate the data. Later you can save this data to a database table.

Understanding DataAdapter

`DataAdapter` is a bridge between the underlying data source and the `DataSet`. `DataAdapter` comes into the picture when you want to perform any of the following:

- Populate the `DataSet` from database data
- Update the data source after modifying the `DataSet` by adding, deleting, or updating `DataRow` objects

Before seeing an example of how to populate a `DataSet` and update the data source, you need to understand the architecture of `DataAdapter`. Take a look at Figure 7-4.

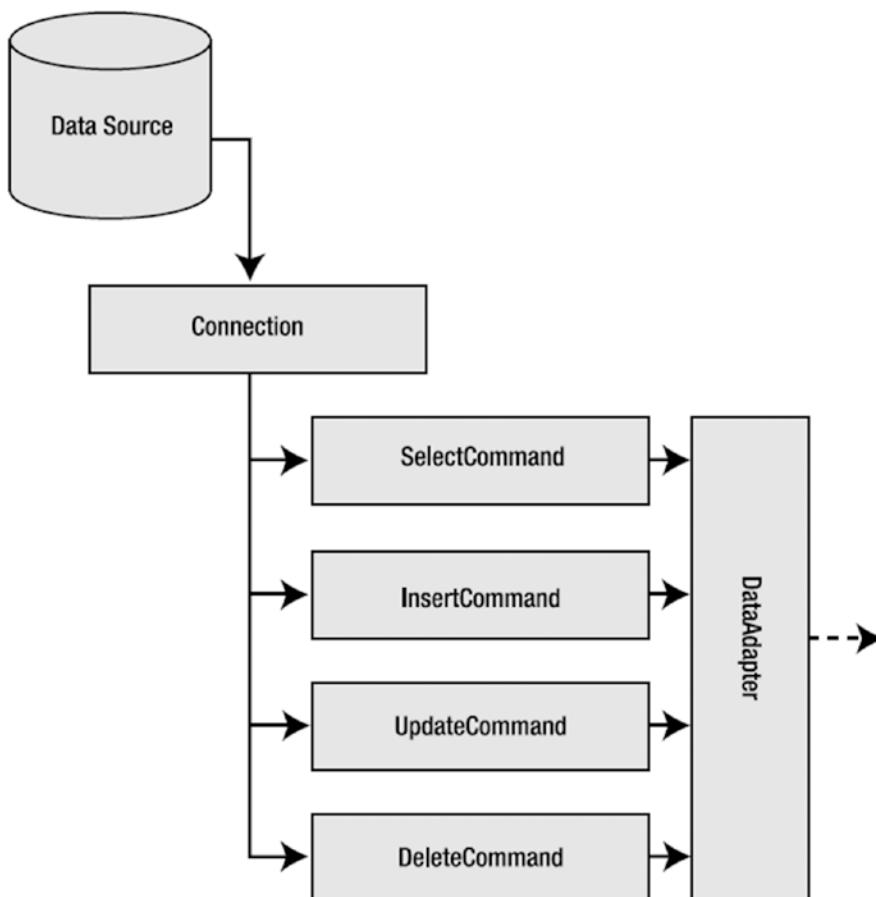


Figure 7-4. DataAdapter architecture

As shown in Figure 7-4, DataAdapter uses four Command objects for executing SELECT, INSERT, UPDATE, and DELETE queries. Each command is represented by the SelectCommand, InsertCommand, UpdateCommand, and DeleteCommand properties of the DataAdapter, respectively. Note that these Command objects are the same as you saw in connected data access. However, each one is assigned a specific task of selecting, inserting, updating, and deleting records from the data source. As with standard Command objects, the CommandText property of these command objects can be any valid SQL query or stored procedure.

DataAdapter provides the Fill() method that uses the Command object specified by the SelectCommand property and populates the DataSet. If you change the DataSet populated by the preceding method and want to propagate the changes back to the underlying data source, you need to set other properties (InsertCommand, UpdateCommand, and so forth) to valid Command instances. DataAdapter provides another method called Update() that uses the Command objects specified by the InsertCommand, UpdateCommand, and DeleteCommand properties and takes the changes from a DataSet back to the underlying data source.

Working with DataSet and DataAdapter

To understand how `DataSet` and `DataAdapter` can be used to manipulate data, you will create an application like the one shown in Figure 7-5.

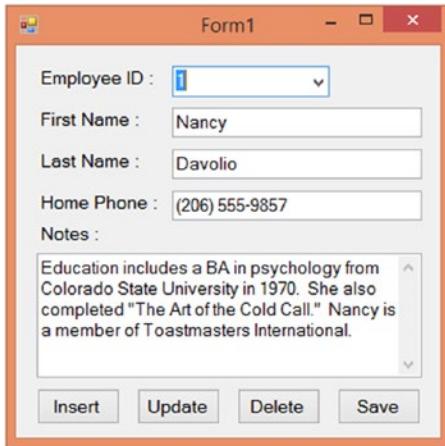


Figure 7-5. Application to illustrate `DataSet` functionality

The application is a typical data-entry screen. The combo box shows a list of all employee IDs. After you select an employee ID, the details of that employee (first name, last name, home phone, and notes) are displayed in the text boxes. The Insert, Update, and Delete buttons perform the respective operations. All the operations—`INSERT`, `UPDATE`, and `DELETE`—are performed on the `DataSet` and not against the actual database table. After all the operations are completed, you can click the Save button to make all the changes in the actual database. The application uses the `Employees` table of the Northwind database.

Now let's dissect the application step by step and see how `DataSet` and `DataAdapter` have been put to use.

Filling a DataSet

If you see the source code of the preceding application, you will find a few variables declared at the form level. The declaration is shown in Listing 7-3.

Listing 7-3. Form-Level Variables

```
string strConn = @"data source=.\sqlexpress;initial catalog=northwind; integrated security=true";
DataSet ds = new DataSet();
SqlDataAdapter da = new SqlDataAdapter();
SqlConnection cnn;
```

The `strConn` string variable stores the database connection string, which uses a local installation of SQL Server Express as indicated by the `data source` attribute. Then variables of type `DataSet`, `SqlDataAdapter`, and `SqlConnection` are declared. You must ensure that you have imported the `System.Data` and `System.Data.SqlClient` namespaces before you declare these variables.

The `Form_Load` event handler of the form contains the code shown in Listing 7-4.

Listing 7-4. Filling a DataSet

```
private void Form1_Load(object sender, EventArgs e)
{
    cnn = new SqlConnection(strConn);
    SqlCommand cmdEmployees = new SqlCommand();
    cmdEmployees.CommandText = "SELECT * FROM employees";
    cmdEmployees.Connection = cnn;
    da.SelectCommand = cmdEmployees;
    da.Fill(ds, "Employees");
    FillEmployees();
}
```

The code creates a `SqlCommand` object and sets its `CommandText` property to fetch all the records from the `Employees` table. The `Connection` property is set to the `SqlConnection` object created earlier. The `SqlCommand` object just created is assigned to the `SelectCommand` property of the `SqlDataAdapter` instance. The `SelectCommand` property determines the records to be populated in the `DataSet` later.

Next, the `Fill()` method of the `SqlDataAdapter` is called. It takes two parameters: the `DataSet` to be filled and the name of the resultant `DataTable`. Notice that the code neither opens the connection nor closes it. This is so because the `SqlDataAdapter` class does that internally for us. Finally, a helper method, `FillEmployees()`, is called and fills the combo box with the list of employee IDs. The `FillEmployees()` method is discussed later.

Note The `SqlDataAdapter` class closes the connection automatically for us only if opened by `SqlDataAdapter` itself. If the connection is opened prior to calling the `Fill()` method, `SqlDataAdapter` will not close it automatically.

Accessing Data from DataSet

When you select an employee ID from the combo box, the employee details should be displayed in the other text boxes. The relevant code is written in the `SelectedIndexChanged` event of the combo box and is shown in Listing 7-5.

Listing 7-5. Accessing Data from a DataSet

```
private void comboBox1_SelectedIndexChanged(object sender, EventArgs e)
{
    string id = comboBox1.SelectedItem.ToString();
    DataRow[] rows = ds.Tables["Employees"].Select($"EmployeeID={id}");
    textBox1.Text = rows[0]["firstname"].ToString();
    textBox2.Text = rows[0]["lastname"].ToString();
    textBox3.Text = rows[0]["homephone"].ToString();
    textBox4.Text = rows[0]["notes"].ToString();
}
```

The code first stores the selected employee ID in a string variable. To find the corresponding employee record from the `DataSet`, we use the `Select()` method of `DataTable`, which accepts the selection criteria and returns an array of `DataRow` objects matching those criteria. In our example, we need to select the employee whose `EmployeeID` column value matches the one selected in the combo box. `EmployeeID` is the primary key column for the `Employees` table and hence we know that it will return only one `DataRow`. The `DataRow` can

be accessed by using typical array notation. Notice how the column names are used to access the individual column values. Instead of column names, you could have used column indexes. The various column values are displayed in the respective text boxes.

Adding New Rows

After you enter details of a new employee to be added and click the Insert button, a new row is added to the underlying DataTable. The code that makes it possible is shown in Listing 7-6.

Listing 7-6. Adding a New DataRow

```
private void button2_Click(object sender, EventArgs e)
{
    DataRow row = ds.Tables["Employees"].NewRow();
    row["employeeid"] = comboBox1.Text;
    row["firstname"] = textBox1.Text;
    row["lastname"] = textBox2.Text;
    row["homephone"] = textBox3.Text;
    row["notes"] = textBox4.Text;
    ds.Tables["Employees"].Rows.Add(row);
    FillEmployees();
}
```

The code creates a new DataRow by calling the `NewRow()` method on the `Employees` DataTable. The `NewRow()` method creates a new stand-alone row in memory, matching the schema of the underlying DataTable. Then various column values of the DataRow are assigned. The newly created row is not yet part of the DataTable, so to add it to the DataTable, the `Add()` method of the `Rows` collection is called. Finally, the combo box is repopulated so as to display the newly added employee ID.

Updating an Existing Row

To update an existing row, you must find it first and then update the column values. To find a specific row, you can use the same `Select()` method that we used earlier. This is shown in Listing 7-7.

Listing 7-7. Updating a DataRow

```
private void button1_Click(object sender, EventArgs e)
{
    if (comboBox1.SelectedItem == null)
    {
        MessageBox.Show("Please select Employee ID!");
        return;
    }
    string id = comboBox1.SelectedItem.ToString();
    DataRow[] rows = ds.Tables["Employees"].Select($"EmployeeID={id}");
    rows[0].BeginEdit();
    rows[0]["firstname"] = textBox1.Text;
    rows[0]["lastname"] = textBox2.Text;
    rows[0]["homephone"] = textBox3.Text;
    rows[0]["notes"] = textBox4.Text;
    rows[0].EndEdit();
}
```

The code selects the employee record that is to be updated by using the `Select()` method of the `DataTable`. The `BeginEdit()` method of the `DataRow` class takes the row in edit mode. The column values are then assigned. Finally, the `EndEdit()` method of the `DataRow` class is called. This saves the changes to the underlying `DataTable`.

Deleting a Row

To delete a row, you must locate it first and then call the `Delete()` method on it. This is illustrated in Listing 7-8.

Listing 7-8. Deleting a `DataRow`

```
private void button3_Click(object sender, EventArgs e)
{
    if (comboBox1.SelectedItem == null)
    {
        MessageBox.Show("Please select Employee ID!");
        return;
    }
    string id = comboBox1.SelectedItem.ToString();
    DataRow[] rows = ds.Tables["Employees"].Select($"EmployeeID={id}");
    rows[0].Delete();
    FillEmployees();
}
```

The code retrieves the row to be deleted by using the `Select()` method of the `DataTable` class. The `Delete()` method of the `DataRow` class marks the underlying row for deletion. Finally, the combo box is repopulated so that the deleted employee ID doesn't show up.

Using `DataRow` States

In the preceding sections, you inserted, updated, and deleted `DataRow` objects from a `DataTable`. Whenever you perform any of these operations (insert, update, or delete) on a `DataRow`, its `RowState` property is affected automatically. The `RowState` property is an enumeration of type `DataRowState` and indicates the state of the `DataRow`. Table 7-1 shows various possible values of the `DataRowState` enumeration.

Table 7-1. `DataRowState` Enumeration

RowState Setting	Description
Unchanged	The row is unchanged since it was placed in the <code>DataSet</code> .
Added	The row is newly added to the <code>DataTable</code> .
Modified	The row is changed.
Deleted	The row is deleted from the <code>DataTable</code> .
Detached	The row is created but not yet attached to the <code>DataTable</code> .

The RowState property is used by the helper function `FillEmployees()`, as shown in Listing 7-9.

Listing 7-9. Using the RowState Property

```
private void FillEmployees()
{
    comboBox1.Items.Clear();
    foreach (DataRow row in ds.Tables["Employees"].Rows)
    {
        if (row.RowState != DataRowState.Deleted)
        {
            comboBox1.Items.Add(row["EmployeeID"].ToString());
        }
    }
}
```

The `FillEmployees()` method simply iterates through each `DataRow` from the `Employees` `DataTable` and adds the `EmployeeID` to the combo box. Notice the code marked in bold. Before adding any value in the combo box, the code checks whether the `RowState` of the row is `Deleted`. Only those rows whose `RowState` is not `Deleted` are added to the combo box.

Saving the Changes to the Database

Up until now, all the changes that we made are saved in the `DataSet` only; they are yet to be committed back to the database. You can test this by making some changes to the records and then closing the application without clicking the Save button. You will observe that the changes are lost. The `Click` event handler of the Save button contains code that propagates changes from the `DataSet` back to the database. Listing 7-10 shows this code.

Listing 7-10. Saving the `DataSet` Changes to the Database

```
private void button4_Click(object sender, EventArgs e)
{
    SqlCommand cmdInsert = new SqlCommand();
    SqlCommand cmdUpdate = new SqlCommand();
    SqlCommand cmdDelete = new SqlCommand();
    cmdInsert.Connection = cnn;
    cmdUpdate.Connection = cnn;
    cmdDelete.Connection = cnn;
    cmdInsert.CommandText =
        "INSERT INTO employees(firstname,lastname,homephone,notes)
         VALUES(@fname,@lname,@phone,@notes)";
    cmdUpdate.CommandText =
        "UPDATE employees SET firstname=@fname,lastname=@lname,homephone=@phone
         WHERE employeeid=@empid";
    cmdDelete.CommandText = "DELETE FROM employees WHERE employeeid=@empid";

    SqlParameter[] pInsert = new SqlParameter[4];
    pInsert[0] = new SqlParameter("@fname", SqlDbType.VarChar);
    pInsert[0].SourceColumn = "firstname";
    pInsert[1] = new SqlParameter("@lname", SqlDbType.VarChar);
```

```

pInsert[1].SourceColumn = "lastname";
pInsert[2] = new SqlParameter("@phone", SqlDbType.VarChar);
pInsert[2].SourceColumn = "homephone";
pInsert[3] = new SqlParameter("@notes", SqlDbType.VarChar);
pInsert[3].SourceColumn = "notes";
foreach (SqlParameter p in pInsert)
{
    cmdInsert.Parameters.Add(p);
}
SqlParameter[] pUpdate = new SqlParameter[5];
pUpdate[0] = new SqlParameter("@fname", SqlDbType.VarChar);
pUpdate[0].SourceColumn = "firstname";
pUpdate[1] = new SqlParameter("@lname", SqlDbType.VarChar);
pUpdate[1].SourceColumn = "lastname";
pUpdate[2] = new SqlParameter("@phone", SqlDbType.VarChar);
pUpdate[2].SourceColumn = "homephone";
pUpdate[3] = new SqlParameter("@notes", SqlDbType.VarChar);
pUpdate[3].SourceColumn = "notes";
pUpdate[4] = new SqlParameter("@empid", SqlDbType.VarChar);
pUpdate[4].SourceColumn = "employeeid";
foreach (SqlParameter p in pUpdate)
{
    cmdUpdate.Parameters.Add(p);
}

SqlParameter[] pDelete = new SqlParameter[1];
pDelete[0] = new SqlParameter("@empid", SqlDbType.VarChar);
pDelete[0].SourceColumn = "employeeid";
foreach (SqlParameter p in pDelete)
{
    cmdDelete.Parameters.Add(p);
}

da.InsertCommand = cmdInsert;
da.UpdateCommand = cmdUpdate;
da.DeleteCommand = cmdDelete;
da.Update(ds, "Employees");
ds.AcceptChanges();
}

```

The code creates three `SqlCommand` objects for INSERT, UPDATE, and DELETE operations, respectively. The `Connection` property of these `SqlCommand` objects is set to the same `SqlConnection` object that we declared at the top initially. The `CommandText` property of each `SqlCommand` is set to the corresponding SQL statement. Note the use of the @ character to represent parameters. For each of these parameter placeholders, a `SqlParameter` object needs to be created. This is done by declaring three arrays of the `SqlParameter` objects: `pInsert`, `pUpdate`, and `pDelete`.

Then each array element is instantiated as a `SqlParameter` object by passing the parameter name and parameter data type in the constructor of the `SqlParameter` class. The `SourceColumn` property of `SqlParameter` specifies the name of the `DataTable` column that will be supplying the value for the parameter. All the parameters from the corresponding arrays are added to the `Parameters` collection of the respective `SqlCommand` object. These three `SqlCommand` objects are assigned to the `InsertCommand`, `UpdateCommand`, and `DeleteCommand` properties of the `SqlDataAdapter` instance that we declared at the top.

The `Update()` method of the `SqlDataAdapter` class is then called and takes all the changes—inserts, updates, and deletes—from the `DataSet` back to the database. The `Update()` method takes two parameters: the `DataSet` to be updated, and the name of the `DataTable` from the `DataSet` that is to be updated. After the changes are saved to the underlying database, the `RowState` properties of all the `DataRow` objects must become `Unchanged`. This is done by calling the `AcceptChanges()` method of the `DataSet` class.

That's it! You can now run the application and test it for the expected functionality.

Saving DataSet Contents As XML

One of the powerful features of the `DataSet` class is that you can serialize it in XML format, which means that relational data can be saved in XML format. This feature comes in handy while working in offline mode and while transporting data to heterogeneous systems.

The `WriteXml()` method of the `DataSet` class writes the contents of the `DataSet` to a stream or physical file in XML format. Optionally, you can also add schema information. To illustrate the use of `WriteXml()`, you need to create an application like the one shown in Figure 7-6.

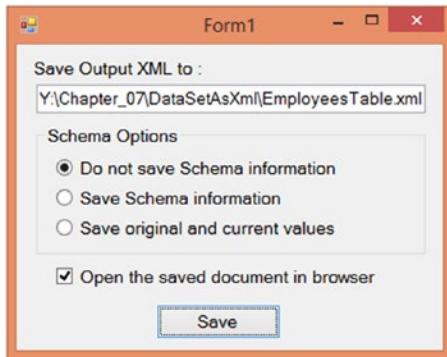


Figure 7-6. Application that writes `DataSet` contents as an XML file

The application consists of a text box for specifying the path of the output XML file. The first two radio buttons specify whether schema information is to be included. The last radio button specifies whether you want to write the original as well as current values to the file. If you select this radio button, the DiffGrams of the original and current values are written in the file.

Note *DiffGram* is a special XML format that stores original as well as current row values. SQL Server 2000 introduced capabilities to update the database via `UpdateGrams`. `DiffGram` is a subset of `UpdateGram`.

If selected, the check box opens the saved XML file in a browser. The `Save` button actually writes the `DataSet` to the specified file. The `Click` event handler of the `Save` button contains the code shown in Listing 7-11.

Listing 7-11. Using the WriteXml() Method

```

private void button1_Click(object sender, EventArgs e)
{
    DataSet ds = new DataSet();
    SqlDataAdapter da =
        new SqlDataAdapter("SELECT employeeid,firstname,lastname,homophone,notes
                           FROM employees",
                           @"data source=.\sqlexpress;initial catalog=northwind;
                           integrated security=true");
    da.Fill(ds, "employees");
    if (radioButton1.Checked)
    {
        ds.WriteXml(textBox1.Text, XmlWriteMode.IgnoreSchema);
    }
    if (radioButton2.Checked)
    {
        ds.WriteXml(textBox1.Text, XmlWriteMode.WriteSchema);
    }
    if (radioButton3.Checked)
    {
        foreach (DataRow row in ds.Tables[0].Rows)
        {
            row.SetModified();
        }
        ds.WriteXml(textBox1.Text, XmlWriteMode.DiffGram);
    }
    if (checkBox1.Checked)
    {
        Process.Start(textBox1.Text);
    }
}

```

The code creates a new `DataSet` and a `SqlDataAdapter`. One of the overloads of the `SqlDataAdapter` constructors accepts the `SELECT` query and database connection string, and it is this overload that we use. The `DataSet` is then filled by using the `Fill()` method of the `DataAdapter`. The name of the `DataTable` is specified as `employees`.

Then a series of `if` conditions checks the status of the radio buttons. In each of the `if` conditions, the `WriteXml()` method of the `DataSet` class is called, which writes the contents of the `DataSet` to the specified stream or disk file. Notice that although each of the `if` conditions calls `WriteXml()`, the second parameter—`XmlWriteMode`—is different in each case.

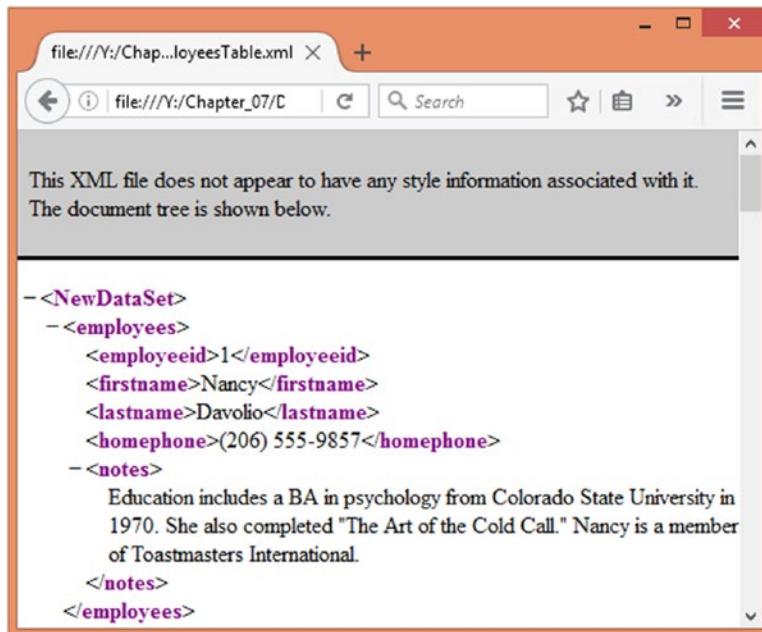
The `XmlWriteMode` enumeration governs two things. First, it specifies whether schema information is to be written along with the XML contents. Second, it decides whether the output XML data will contain just the current values or both the original and current values. As you saw in the preceding example, the latter format is called `DiffGram`. The three possible values of the `XmlWriteMode` enumeration are shown in Table 7-2.

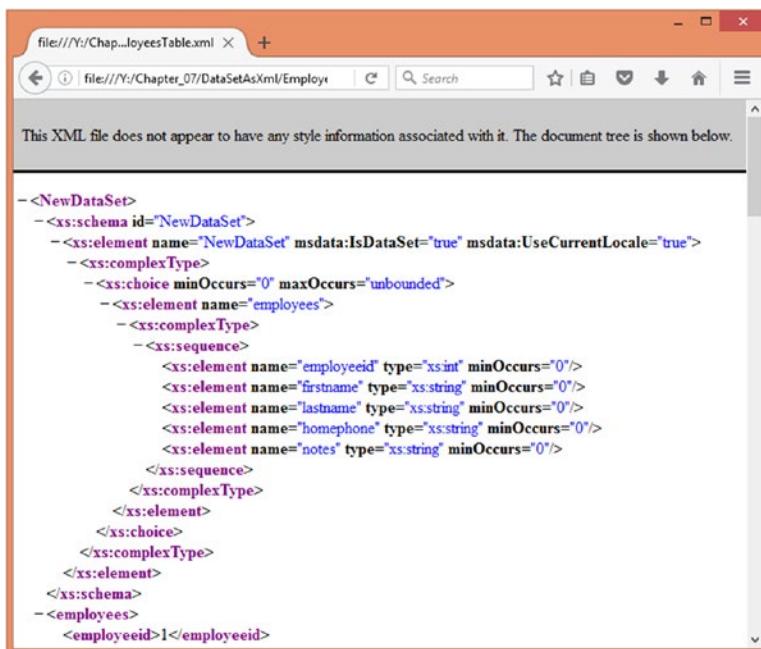
Table 7-2. *XmlWriteMode Values*

Value	Description
IgnoreSchema	Writes the contents of the DataSet as XML data. No XSD Schema information is written.
WriteSchema	Writes the contents of the DataSet as XML data. Also, writes XSD Schema information along with the data.
DiffGram	Writes the contents of the DataSet as DiffGram XML markup. The DiffGram stores the current as well as original column values.

Notice the if condition for radioButton3. Because we have not made any changes to the DataSet as such, the code deliberately marks each row as modified. This is done by using the SetModified() method of the DataRow class. This way, we will be able to see how the DiffGram format stores old and new values.

Finally, the saved XML file is opened in a browser by using the Start() method of the Process class. Figure 7-7 shows a sample run of the application without saving any schema information. Similarly, Figures 7-8 and 7-9 show the output XML file with schema information and DiffGram, respectively.

**Figure 7-7.** Writing DataSet as XML without schema information



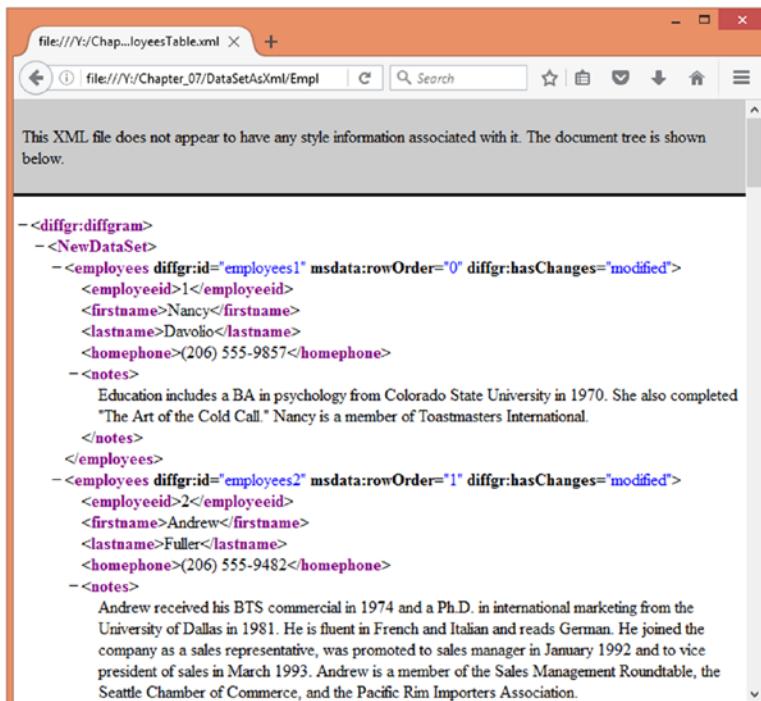
This XML file does not appear to have any style information associated with it. The document tree is shown below.

```

-<NewDataSet>
- <x: schema id="NewDataSet">
- <x: element name="NewDataSet" msdata: IsDataSet="true" msdata: UseCurrentLocale="true">
- <x: complexType>
- <x: choice minOccurs="0" maxOccurs="unbounded">
- <x: element name="employees">
- <x: complexType>
- <x: sequence>
- <x: element name="employeeid" type="xs:int" minOccurs="0"/>
- <x: element name="firstname" type="xs:string" minOccurs="0"/>
- <x: element name="lastname" type="xs:string" minOccurs="0"/>
- <x: element name="homephone" type="xs:string" minOccurs="0"/>
- <x: element name="notes" type="xs:string" minOccurs="0"/>
</x: sequence>
<x: complexType>
<x: element>
<x: choice>
<x: complexType>
<x: element>
</x: schema>
- <employees>
<employeeid>1</employeeid>

```

Figure 7-8. Writing DataSet as XML with schema information



This XML file does not appear to have any style information associated with it. The document tree is shown below.

```

-<diffgr:diffgram>
- <NewDataSet>
- <employees diffgr:id="employees1" msdata:rowOrder="0" diffgr:hasChanges="modified">
<employeeid>1</employeeid>
<firstname>Nancy</firstname>
<lastname>Davolio</lastname>
<homephone>(206) 555-9857</homephone>
- <notes>
Education includes a BA in psychology from Colorado State University in 1970. She also completed "The Art of the Cold Call." Nancy is a member of Toastmasters International.
</notes>
</employees>
- <employees diffgr:id="employees2" msdata:rowOrder="1" diffgr:hasChanges="modified">
<employeeid>2</employeeid>
<firstname>Andrew</firstname>
<lastname>Fuller</lastname>
<homephone>(206) 555-9482</homephone>
- <notes>
Andrew received his BTS commercial in 1974 and a Ph.D. in international marketing from the University of Dallas in 1981. He is fluent in French and Italian and reads German. He joined the company as a sales representative, was promoted to sales manager in January 1992 and to vice president of sales in March 1993. Andrew is a member of the Sales Management Roundtable, the Seattle Chamber of Commerce, and the Pacific Rim Importers Association.
</notes>

```

Figure 7-9. Writing DataSet as XML in DiffGram format

Notice how the schema information is emitted in Figure 7-8. Also, examine Figure 7-9 carefully. This XML output is in DiffGram format. See how the `<diffgr:before>` section stores the original values of the `DataRow`s, whereas the current values are displayed at the top.

Saving Only the Schema

The `WriteXml()` method writes data and optionally XSD Schema information. What if you need to extract only the schema information and not the data itself? The `WriteXmlSchema()` method does that job by writing only the schema of the `DataSet` and not the data. To illustrate the use of `WriteXmlSchema()`, you can modify the preceding application to include an additional radio button. The new interface of the application is shown in Figure 7-10.

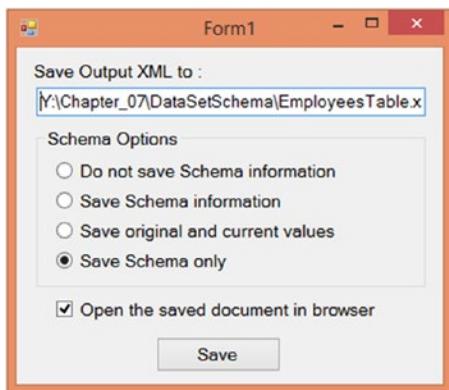


Figure 7-10. Application for illustrating the `WriteXmlSchema()` method

If you select the newly added radio button titled Save Schema only, only the schema of the `DataSet` will be saved. Listing 7-12 shows the modified version of the code.

Listing 7-12. Using the `WriteXmlSchema()` Method

```
private void button1_Click(object sender, EventArgs e)
{
    DataSet ds = new DataSet();
    SqlDataAdapter da =
        new SqlDataAdapter("SELECT employeeid,firstname,lastname,homophone,notes
                           FROM employees",
                           @"data source=.\sqlexpress;initial catalog=northwind;
                           integrated security=true");
    da.Fill(ds, "employees");
    if (radioButton1.Checked)
    {
        ds.WriteXml(textBox1.Text, XmlWriteMode.IgnoreSchema);
    }
    if (radioButton2.Checked)
    {
        ds.WriteXml(textBox1.Text, XmlWriteMode.WriteSchema);
    }
}
```

```

if (radioButton3.Checked)
{
    foreach (DataRow row in ds.Tables[0].Rows)
    {
        row.SetModified();
    }
    ds.WriteXml(textBox1.Text, XmlWriteMode.DiffGram);
}
if (radioButton4.Checked)
{
    ds.WriteXmlSchema(textBox1.Text);
}
if (checkBox1.Checked)
{
    Process.Start(textBox1.Text);
}
}

```

Notice the code marked in bold. The code calls the `WriteXmlSchema()` method by passing the file in which the schema information will be stored. You will observe that the schema obtained by this method is the same as that obtained by the `WriteXml()` method with `XmlWriteMode.WriteSchema`. However, no data is written to the file.

Extracting DataSet Contents As an XML String

The `WriteXml()` and `WriteXmlSchema()` methods write XML data and schema to a stream or file, respectively. Sometimes you may want to get the XML data and schema as a string rather than writing to a file. This is accomplished with two methods:

- The `GetXml()` method returns just the contents of the `DataSet` in XML format as a string. No schema information is returned.
- Similarly, the `GetXmlSchema()` method returns the XML Schema of the `DataSet` as a string. Because these methods return strings, they incur more overhead than `WriteXml()` and `WriteXmlSchema()`.

Reading XML Data into DataSet

In the preceding sections, you learned to serialize `DataSet` contents as XML data. There might be cases when you would like to do the opposite—that is, you may need to read XML data into a `DataSet` and process it further. The `ReadXml()` method of the `DataSet` class is the counterpart of the `WriteXml()` method that we discussed already and allows you to read XML data into a `DataSet`.

Note In the following examples, you will frequently need XML files containing a schema and data. It is recommended that you run the preceding example (Figure 7-10) and save the resultant XML files on your disk for later use.

To illustrate the use of `ReadXml()`, you need to develop an application like the one shown in Figure 7-11.

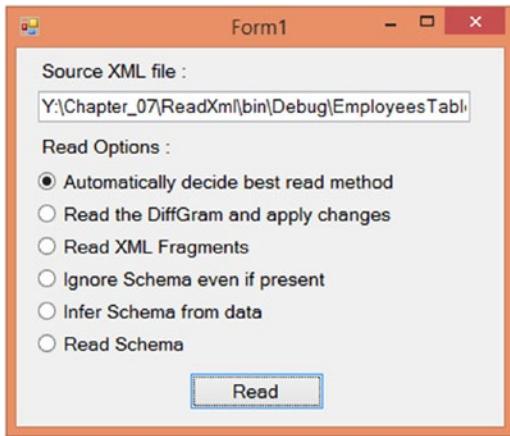


Figure 7-11. Application that reads XML data into a DataSet

The application consists of a text box for accepting the source XML file path. There is an array of radio buttons that govern how the XML document will be read by the DataSet. The Read button triggers the read operation. Listing 7-13 shows the complete code that reads the XML data into a DataSet.

Listing 7-13. Using the ReadXml() Method

```
private void button1_Click(object sender, EventArgs e)
{
    DataSet ds = new DataSet();
    XmlReadMode mode=XmlReadMode.Auto;
    if (radioButton1.Checked)
    {
        mode = XmlReadMode.Auto;
    }
    if (radioButton2.Checked)
    {
        mode = XmlReadMode.DiffGram;
    }
    if (radioButton3.Checked)
    {
        mode = XmlReadMode.Fragment;
    }
    if (radioButton4.Checked)
    {
        mode = XmlReadMode.IgnoreSchema;
    }
    if (radioButton5.Checked)
    {
        mode = XmlReadMode.InferSchema;
    }
    if (radioButton6.Checked)
    {
        mode = XmlReadMode.ReadSchema;
    }
}
```

```

ds.ReadXml(textBox1.Text, mode);
MessageBox.Show("XML file read successfully!");
}

```

The code creates a new `DataSet` object. It then declares a variable of enumeration type `XmlReadMode`. This enumeration plays an important role in deciding how the XML data will be loaded into the `DataSet`. You can see all the possible values of the `XmlReadMode` enumeration in Table 7-3. Then a series of if conditions checks the status of the various radio buttons and sets the value of the `XmlReadMode` variable. Finally, the `ReadXml()` method of the `DataSet` class is called.

Table 7-3. *XmlReadMode Values*

Value	Description
Auto	Uses the most appropriate read mode from the remaining values (the default)
DiffGram	Loads a DiffGram and applies the changes
Fragment	Loads XML fragments such as the ones created when using the FOR XML clause
IgnoreSchema	Ignores the inline schema present in the source XML document
InferSchema	Infers the schema from the data present and loads the data into the <code>DataSet</code>
ReadSchema	Reads the inline schema present in the XML document

The `ReadXml()` method has several overloads. The one that we use accepts the name of the XML file to read and the `XmlReadMode` value. After `ReadXml()` has finished, the `DataSet` has populated `DataTable` objects depending on the source XML document. For example, if you use the `EmployeesTable.xml` file that we created previously, your `DataSet` will contain one `DataTable` called `employees`.

The `XmlReadMode` options need more explanation because there are a number of possibilities during the read operation. These options are discussed next.

Using the Automatic Read Operation

The `Auto` option of the `XmlReadMode` enumeration uses the most appropriate mechanism while loading the XML data. If the data is a `DiffGram`, it sets `XmlReadMode` to `DiffGram`. If the `DataSet` already has a schema or the XML document contains an inline schema, it sets `XmlReadMode` to `ReadSchema`. Finally, if the `DataSet` does not already have a schema and the XML document does not contain an inline schema, it sets `XmlReadMode` to `InferSchema`.

Reading DiffGrams

The `DiffGram` option of the `XmlReadMode` enumeration is exclusively used with `DiffGrams`. Generally, these `DiffGrams` will be generated by using the `WriteXml()` method of `DataSet`. The schema of the `DataSet` and the `DiffGram` must match in order to successfully read the data. Because the `DiffGram` stores the original and current values of `DataRow`s, the changes are applied after the `DiffGram` is loaded in the `DataSet`.

Reading XML Fragments

In the earlier sections of this chapter, you learned that SQL Server provides an extension to the normal `SELECT` statement in the form of the `FOR XML` clause. You also saw how the `FOR XML` clause returns XML data in the form of fragments. If you want to load these XML fragments into a `DataSet`, you must set `XmlReadMode` to `Fragment`.

Ignoring Schema Information

The XML document that you want to load into a `DataSet` might contain schema information embedded in it. If you want to ignore this schema, you must use the `IgnoreSchema` option of the `XmlReadMode` enumeration. If the `DataSet` already has a schema and the XML data being loaded doesn't match this schema, the data is discarded.

Inferring Schema Information

The `InferSchema` option of `XmlReadMode` ignores schema information from the source XML data if present and loads the data into a `DataSet`. If the `DataSet` already has its schema, that is extended to accommodate the new data. However, if there is any mismatch between the existing schema and the newly inferred schema, an exception is raised.

Reading Schema Information

The `ReadSchema` option of `XmlReadMode` reads the inline schema from the source XML document and loads the schema as well as the data into the `DataSet`. If the `DataSet` already contains a schema, it is extended as per the new schema. However, any mismatch between the existing schema and the new schema causes an exception to be thrown.

Generating Menus Dynamically Based On an XML File

The `ReadXml()` method performs many operations behind the scenes to make our task easier. To get a taste of what it does, you will develop a Windows application that dynamically adds menu items. The application will resemble the one shown in Figure 7-12.

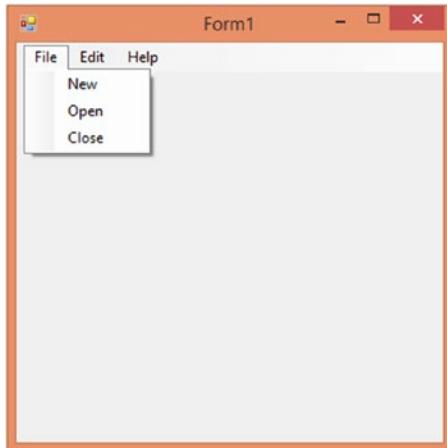


Figure 7-12. Form showing dynamically loaded menu items

The form consists of a single `MenuStrip` control. The menu items are stored in an XML file, as shown in Listing 7-14. Save this file as `menus.xml` in your application's `Bin\Debug` folder.

Listing 7-14. XML File Representing the Menu Structure

```
<?xml version="1.0" encoding="utf-8" ?>
<menus>
    <topmenu text="File">
        <submenu>New</submenu>
        <submenu>Open</submenu>
        <submenu>Close</submenu>
    </topmenu>
    <topmenu text="Edit">
        <submenu>Cut</submenu>
        <submenu>Copy</submenu>
        <submenu>Paste</submenu>
    </topmenu>
    <topmenu text="Help">
        <submenu>Help</submenu>
        <submenu>Search</submenu>
        <submenu>About</submenu>
    </topmenu>
</menus>
```

The root element of the XML file is `<menus>`. Inside there can be zero or more `<topmenu>` items, which represent the top-level menu items. The `text` attribute of `<topmenu>` indicates the text of that menu. The `<topmenu>` element can contain zero or more `<submenu>` elements, which indicate submenus of the top-level menus. The text of the submenus is specified in the `<submenu>` element's value.

Let's see how this file can be loaded in a `DataSet` and how the data can be accessed. Listing 7-15 shows the `Load` event handler of the form with the required code.

Listing 7-15. Adding Menu Items Dynamically

```
private void Form1_Load(object sender, EventArgs e)
{
    DataSet ds = new DataSet();
    ds.ReadXml($"{Application.StartupPath}\\menus.xml");

    foreach (DataRow topmenu in ds.Tables[0].Rows)
    {
        ToolStripMenuItem item = new ToolStripMenuItem(topmenu["text"].ToString());
        menuStrip1.Items.Add(item);
        DataRow[] submenus = topmenu.GetChildRows(ds.Relations[0]);
        foreach (DataRow submenu in submenus)
        {
            item.DropDownItems.Add(submenu[0].ToString());
        }
    }
}
```

The code creates a new `DataSet` and reads the `menus.xml` file that we created earlier. While reading this file, the `DataSet` does some interesting things:

1. It observes the nesting of the XML data in the file and creates two `DataTable` objects. The first `DataTable` stores all the top menus, and the second `DataTable` stores all the submenus.
2. It creates `DataRow` objects in the top-menu `DataTable` and adds a `DataColumn` to them. The value contained in these columns is the value of the `text` attribute of the `<topmenu>` element.
3. It does a similar thing for the submenus `DataTable`, but loads the element values of the `<submenu>` items in the column.
4. It sets a `DataRelation` between the two tables by automatically adding an integer column to both of these `DataTable` objects.

The code then iterates through all the rows from the first `DataTable` (the `DataTable` storing the top menus) and adds `ToolStripMenuItem` objects to the `MenuStrip`. The `GetChildRows()` method is called on each `DataRow` of the topmenu `DataTable`. This method accepts a `DataRelation` object and returns all the `DataRow` objects from the child table matching that relationship. In our case, the submenu `DataTable` is the child `DataTable`. The return value of `GetChildRows()` is an array of `DataRow` objects. The second `foreach` loop iterates through all the elements of this array and adds subitems to the `DropDownItems` collection of the `ToolStripMenuItem` class.

If you run the application, you should see something similar to Figure 7-12.

Reading Only the Schema Information

The `ReadXml()` method allows you to read data and optionally schema information. However, at times you may need to extract just the schema information from the XML file and not the data. The `DataSet` class provides two methods that allow you to extract schema information from the source XML. They are `ReadXmlSchema()` and `InferXmlSchema()`.

`ReadXmlSchema()` accepts the XML with an inline schema and reads just the schema part of it. The schema is then loaded into the `DataSet`. What if your XML document doesn't contain an inline schema? That is where the `InferXmlSchema()` method comes into the picture. The `InferXmlSchema()` method observes the XML markup supplied and then creates a matching schema automatically. The schema is then loaded into the `DataSet`.

To illustrate both of these methods, you need to develop an application like the one shown in Figure 7-13.

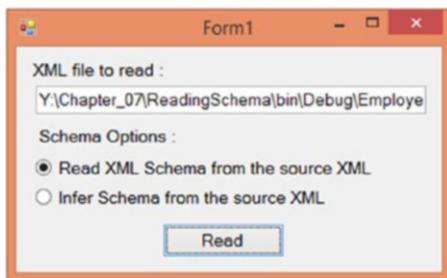


Figure 7-13. Application that reads schema

The application consists of a text box for specifying the source XML file. The two radio buttons enable you to decide whether `ReadXmlSchema()` or `InferXmlSchema()` is to be called. The code for the Read button reads the schema into a `DataSet` and displays it in a message box. The code that reads the schema is shown in Listing 7-16.

Listing 7-16. Using the `ReadXmlSchema()` and `InferXmlSchema()` Methods

```
private void button1_Click(object sender, EventArgs e)
{
    DataSet ds = new DataSet();
    if (radioButton1.Checked)
    {
        ds.ReadXmlSchema(textBox1.Text);
    }
    if (radioButton2.Checked)
    {
        ds.InferXmlSchema(textBox1.Text, null);
    }
    MessageBox.Show(ds.GetXmlSchema());
}
```

The code creates a new `DataSet` object. Depending on the radio button selected, the code calls either `ReadXmlSchema()` or `InferXmlSchema()`. `ReadXmlSchema()` accepts the source XML document as a parameter and loads the inline schema from the document into the `DataSet`. No data is loaded.

The `InferXmlSchema()` method accepts the source XML document and an array of namespaces (null in our example) and infers the schema from the data. Again, no data is loaded. The loaded schema is shown in a message box by calling the `GetXmlSchema()` method of the `DataSet`. Figure 7-14 shows the schema loaded by using `ReadXmlSchema()`, whereas Figure 7-15 shows the schema loaded by using `InferXmlSchema()`.

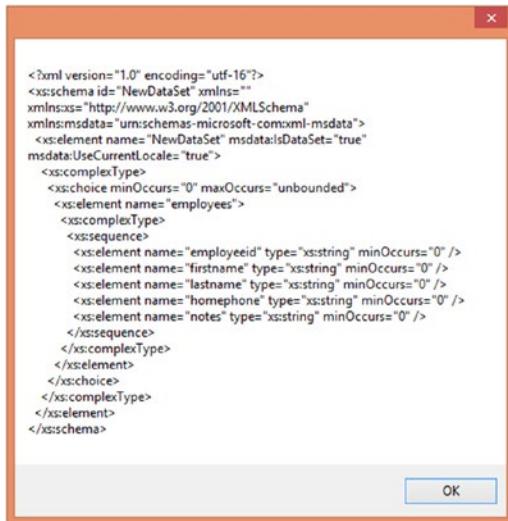


Figure 7-14. Schema extracted by using the `ReadXmlSchema()` method

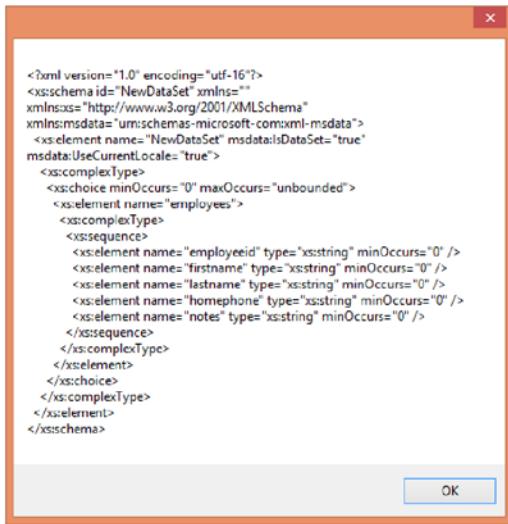


Figure 7-15. Schema extracted by using the InferXmlSchema() method

As you can see, the schema loaded by both methods is identical in our example.

Creating a Typed DataSet

While discussing DataSet and DataAdapter, we developed an application that allowed us to perform inserts, updates, and deletes on a DataSet and then save those changes back to the database (see Figure 7-6). In that application, we frequently used collections such as Tables and Rows. We also needed to remember column names while accessing their values from a DataRow. Don't you think it is a bit tedious to access data in this fashion? To make things clearer, look at Listings 7-17 and 7-18.

Listing 7-17. Inserting a DataRow by Using an Untyped DataSet

```

private void button2_Click(object sender, EventArgs e)
{
    DataRow row = ds.Tables["Employees"].NewRow();
    row["employeeid"] = comboBox1.Text;
    row["firstname"] = textBox1.Text;
    row["lastname"] = textBox2.Text;
    row["homephone"] = textBox3.Text;
    row["notes"] = textBox4.Text;
    ds.Tables["Employees"].Rows.Add(row);
    FillEmployees();
}

```

Listing 7-18. Inserting a DataRow by Using a Typed DataSet

```
private void button2_Click(object sender, EventArgs e)
{
    EmployeesDataSet.EmployeesRow row = ds.Employees.NewEmployeesRow();
    row.EmployeeID = int.Parse(comboBox1.Text);
    row.FirstName = textBox1.Text;
    row.LastName = textBox2.Text;
    row.HomePhone = textBox3.Text;
    row.Notes = textBox4.Text;
    ds.Employees.AddEmployeesRow(row);
    FillEmployees();
}
```

Both of these listings represent code that inserts a new DataRow into a DataTable. Compare the listings carefully. In Listing 7-17, we access the Employees DataTable and its columns by specifying them in double quotes. That means you need to remember these names when you are coding. However, Listing 7-18 looks different. You will notice that it uses the Employees property to create a new row. Further, it uses column names such as FirstName and LastName as if they are properties. Obviously, the second version is far easier to code and is much neater, which demonstrates what typed DataSets are about.

A typed DataSet is a class that internally derives from DataSet as a base class. It extends this base class further and adds certain properties and methods that make the developer's life easy. When using a typed DataSet, you can access DataTable and DataColumn objects by using their strongly typed names instead of the collection syntax. A typed DataSet has an XSD Schema attached to it that defines the DataTable and DataColumn objects of the DataSet.

Using Visual Studio to Create a Typed DataSet

Now that you know what a typed DataSet is, let's create one for our Employees table. To do so, you first need to add a typed DataSet to your project. Figure 7-16 shows the Add New Item dialog box of Visual Studio, through which you can add a new typed DataSet.

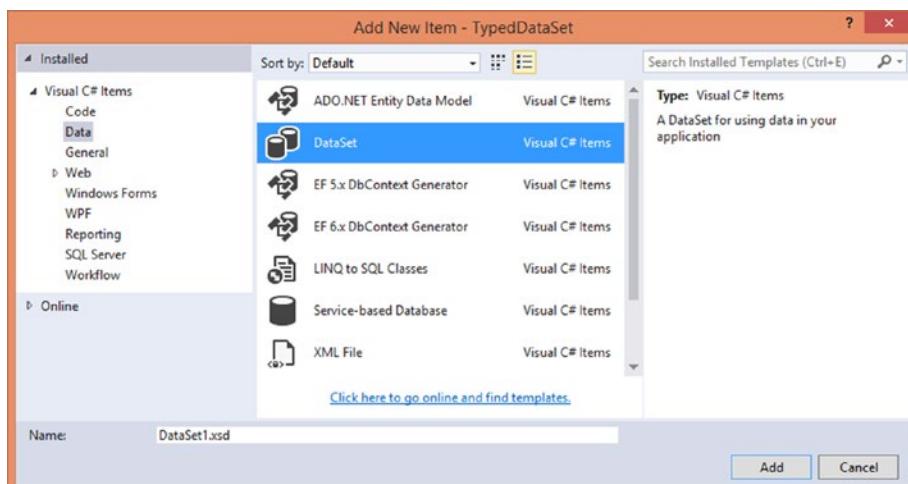


Figure 7-16. Adding a new typed DataSet to your project

After you are on the DataSet designer, you can see the DataSet toolbox, shown in Figure 7-17.

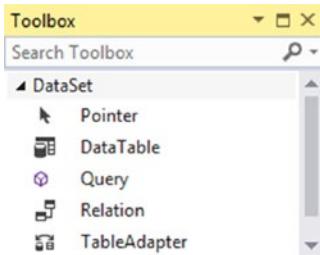


Figure 7-17. The DataSet toolbox

As you can see, the toolbox has items such as DataTable and Relation that you can drag and drop on the DataSet designer. For our example, you need to drag and drop a DataTable on the DataSet designer and set its Name property to Employees. To add columns to the DataTable, you can right-click it and add the required number of columns (see Figure 7-18).

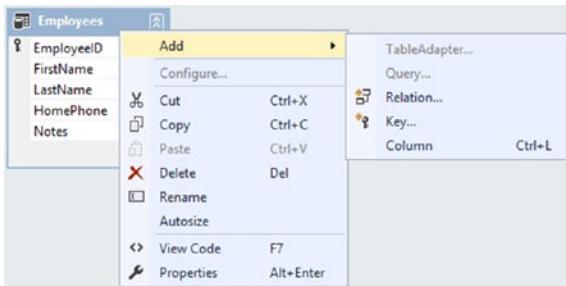


Figure 7-18. Adding columns to a DataTable

The name and data type of each column can then be set via the properties window. For example, Figure 7-19 shows the Properties window for the EmployeeID column.

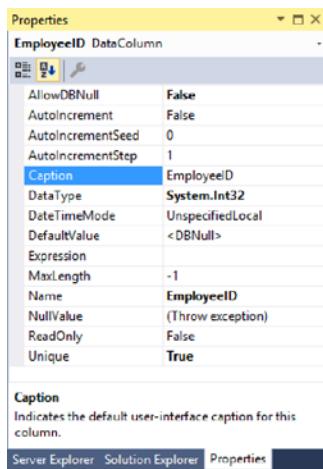


Figure 7-19. Setting properties of the EmployeeID column

After designing the Employees DataTable, it should look like Figure 7-20.

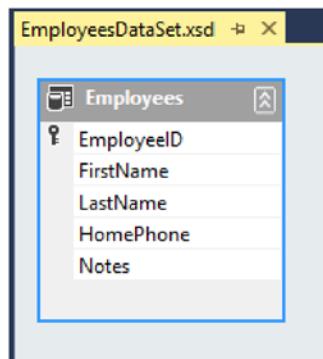


Figure 7-20. The Employees DataTable in the DataSet designer

As you are designing the DataSet in the designer, Visual Studio creates a class that inherits from the DataSet class and adds certain properties and methods to it. It also creates certain support files, as you can see in the Solution Explorer (see Figure 7-21).

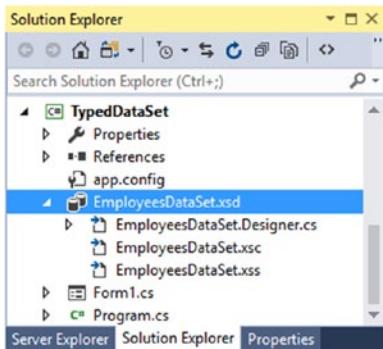


Figure 7-21. EmployeesDataSet and its associated files

Next, you need to design the main form of your application, as shown in Figure 7-22.

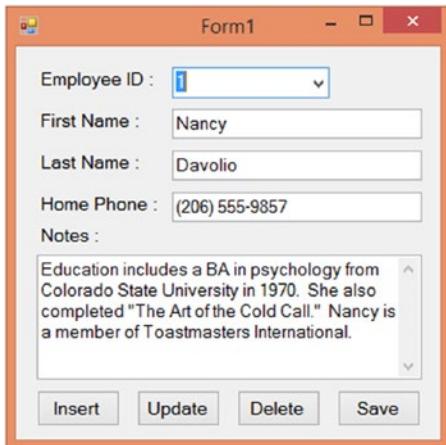


Figure 7-22. Application that consumes a typed DataSet

The application behaves exactly the same as the one shown in Figure 7-6 earlier, but this time it uses our typed DataSet. Listing 7-19 shows the variable declarations at the form level.

Listing 7-19. Declaring a Typed DataSet Variable

```
private string strConn = @"data source=.\sqlexpress;
initial catalog=northwind;integrated security=true";
EmployeesDataSet ds = new EmployeesDataSet();
SqlDataAdapter da = new SqlDataAdapter();
SqlConnection cnn;
```

Notice the line marked in bold. The code declares a variable of our typed DataSet, which bears the same name as the DataSet XSD Schema file. This typed DataSet is filled in the Load event of the form. The code in the Load event remains the same as before, but for the sake of completeness, it's shown in Listing 7-20.

Listing 7-20. Filling a Typed DataSet

```
private void Form1_Load(object sender, EventArgs e)
{
    cnn = new SqlConnection(strConn);
    SqlCommand cmdEmployees = new SqlCommand();
    cmdEmployees.CommandText = "SELECT * FROM employees";
    cmdEmployees.Connection = cnn;
    da.SelectCommand = cmdEmployees;
    da.Fill(ds, "Employees");
    FillEmployees();
}
```

The code uses a `SqlDataAdapter` and calls its `Fill()` method to populate the typed `DataSet`. One thing to note here is that the name of the `DataTable` specified in the `Fill()` method must match the name of the `DataTable` that you created in the typed `DataSet`. Listing 7-21 shows the modified version of the code responsible for inserting, updating, and deleting `DataRow` objects.

Listing 7-21. Inserting, Updating, and Deleting Data from a Typed DataSet

```
private void button2_Click(object sender, EventArgs e)
{
    EmployeesDataSet.EmployeesRow row = ds.Employees.NewEmployeesRow();
    row.EmployeeID = int.Parse(comboBox1.Text);
    row.FirstName = textBox1.Text;
    row.LastName = textBox2.Text;
    row.HomePhone = textBox3.Text;
    row.Notes = textBox4.Text;
    ds.Employees.AddEmployeesRow(row);
    FillEmployees();
}

private void button1_Click(object sender, EventArgs e)
{
    string id = comboBox1.SelectedItem.ToString();
    EmployeesDataSet.EmployeesRow[] rows =
        (EmployeesDataSet.EmployeesRow[])ds.Employees.Select($"EmployeeID={id}");
    rows[0].BeginEdit();
    rows[0].FirstName = textBox1.Text;
    rows[0].LastName = textBox2.Text;
    rows[0].HomePhone = textBox3.Text;
    rows[0].Notes = textBox4.Text;
    rows[0].EndEdit();
}

private void button3_Click(object sender, EventArgs e)
{
    string id = comboBox1.SelectedItem.ToString();
    EmployeesDataSet.EmployeesRow[] rows =
        (EmployeesDataSet.EmployeesRow[])ds.Employees.Select($"EmployeeID={id}");
    rows[0].Delete();
    FillEmployees();
}
```

Notice the changes made to the original code. In the Click event handler of the Insert button, the new DataRow is created by calling NewEmployeesRow(). The typed DataSet automatically show the available DataTable objects as properties, and each DataTable provides the NewEmployeesRow() method to create a new row. The newly created row is of type EmployeesRow, which is a class generated by Visual Studio in the EmployeesDataSet class. EmployeesRow exposes each column of the row as a property, and these properties can then be assigned new values. The newly created row is then added to the Employees DataTable by using its AddEmployeesRow() method. There are similar modifications in the Click event handlers of the Update and Delete buttons.

Using the xsd.exe Tool to Create a Typed DataSet

Though Visual Studio provides a visual way to create typed DataSets, the .NET Framework also provides a command-line tool called xsd.exe that can generate typed DataSets for you. The tool accepts an XML Schema for a DataSet and outputs the typed DataSet class. Though we will not discuss the xsd.exe tool at great length, here is a sample use of it:

```
xsd.exe EmployeesDataSet.xsd /dataset /language:CS /namespace:MyTypedDataSets
```

The command accepts the name of an XML Schema file (EmployeesDataSet.xsd in this case). The /dataset switch indicates that the tool should generate a typed DataSet based on this XML Schema. The /language switch specifies the language to be used for the typed DataSet class. In our example, we specify the language as C# (CS). Finally, the /namespace switch specifies the namespace in which the typed DataSet class will be placed.

The output of the preceding command will be a class file named EmployeesDataSet.cs. You can compile this class file separately into an assembly or add it to your existing project along with other classes.

Summary

ADO.NET is a very important part of the overall .NET Framework. Modern data-driven applications tend to work with relational as well as hierarchical datastores. The ADO.NET object model, though primarily inclined toward RDBMSs, has tight integration with XML.

This chapter gave you a thorough look at the XML features of ADO.NET. You learned how to work with XML data in connected and disconnected mode. The DataSet class is the cornerstone of the ADO.NET disconnected model and allows you to read and write XML data, and to work with schemas. Further, typed DataSets make your development easy by providing typed DataTable and DataColumn names.

CHAPTER 8



XML Serialization

Your .NET applications consist of one or more classes. The objects of these classes are used to store state information. As long as your objects are available in the memory of your application, this state information is readily available. But what if you want to persist object state across application shutdowns? At first you may think of saving object state in a relational database. However, databases generally store information in relational format, whereas objects often have a hierarchical structure. Moreover, you would need to create many tables in the database on your own. Storing object data in a database comes with its own overheads. Wouldn't it be nice if the entire object state could be stored to a medium and retrieved later? That is what serialization offers.

Serialization is a process by which object state is persisted to a medium. The medium can be a physical disk file, memory, or even a network stream. The serialized objects can be retrieved later in your application by a process called *deserialization*. The .NET Framework provides extensive support for serialization and uses serialization in many places. Web services, WCF services, and Web API are a few places where serialization is heavily used. In this chapter, you learn about the following topics:

- Understanding the flavors of serialization
- Using the `XmlSerializer` class to serialize object state in XML format
- Using the `DataContractSerializer` class to serialize object state in XML format
- Using the `SoapFormatter` class to serialize object state in SOAP format
- Customizing the serialization process with the help of certain attributes

Understanding the Flavors of Serialization

Serialization can be classified based on the format of serialization or on the depth of serialization. The three commonly used formats in which you can serialize data in the .NET Framework are as follows:

- *Binary*: This format is generally better in terms of performance than the others. However, in terms of extensibility and cross-application integration, the other formats are better.
- *XML*: Objects serialized in this way are stored as plain XML. If you are talking with multiple heterogeneous systems, this format will prove useful. For example, your .NET applications may serialize objects as XML documents, and a Java application may read these serialized objects by using its standard XML parser and work with the data further.
- *Simple Object Access Protocol (SOAP)*: Objects serialized in this way store information as per the SOAP standards. SOAP is the core pillar for web services. SOAP protocol is based on XML.

Serialization using binary format is beyond the scope of this book. This chapter discusses serialization using XML and SOAP formats.

Note In modern web applications, JSON is increasingly becoming popular as a format for transferring data. Applications using JSON need a mechanism to serialize and deserialize objects in JSON format. Although WCF and Web API can deal with JSON data, we won't discuss that in this book.

The other way to classify serialization is based on the depth of serialization. The two flavors based on the depth of serialization are as follows:

- *Deep serialization*: This serializes all the public, protected, and private members of your class.
- *Shallow serialization*: This serializes only the public members of your class.

In the .NET Framework, the depth of serialization depends on the serializer class you use for the sake of serializing and deserializing objects.

Classes Involved in the XML Serialization

There are three core classes that are used to perform serialization in XML and SOAP formats:

- The `XmlSerializer` class serializes objects in XML format. It resides in the `System.Xml.Serialization` namespace. The `System.Xml.Serialization` namespace physically resides in the `System.Xml.dll` assembly. Serialization done using `XmlSerializer` is shallow in nature.
- The `DataContractSerializer` class serializes objects in XML format. It was added as a part of Windows Communication Foundation (WCF) and resides in the `System.Runtime.Serialization` namespace. Serialization done using `DataContractSerializer` is deep in nature.
- The `SoapFormatter` class serializes objects in SOAP format. It resides in the `System.Runtime.Serialization.Formatters.Soap` namespace. The `System.Runtime.Serialization.Formatters.Soap` namespace physically resides in the `System.Runtime.Serialization.Formatters.Soap.dll` assembly. Serialization done using `SoapFormatter` is deep in nature.

Serializing and Deserializing Objects Using `XmlSerializer`

Now that you have a basic understanding of what serialization is, let's delve straight into XML serialization. You will be building an application that illustrates the serialization and deserialization process by using the `XmlSerializer` class. The application user interface is shown in Figure 8-1.

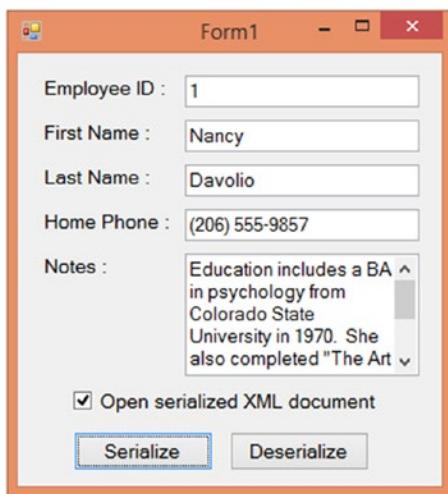


Figure 8-1. Application for illustrating XML serialization

The application consists of a class called `Employee` with five public properties: `EmployeeID`, `FirstName`, `LastName`, `HomePhone`, and `Notes`. There are five text boxes that accept values for these properties. The two buttons, `Serialize` and `Deserialize`, do the job of serializing and deserializing the `Employee` object, respectively. The check box determines whether the serialized XML document will be opened in a browser for viewing.

Before you can use the `XmlSerializer` class, you should create the `Employee` class shown in Listing 8-1.

Listing 8-1. The Employee Class

```
public class Employee
{
    public int EmployeeID { get; set; }
    public string FirstName { get; set; }
    public string LastName { get; set; }
    public string HomePhone { get; set; }
    public string Notes { get; set; }
}
```

The class consists of five public properties for storing various pieces of information about an employee, namely `EmployeeID`, `FirstName`, `LastName`, `HomePhone`, and `Notes`.

The Click event handler of the `Serialize` button contains the code shown in Listing 8-2.

Listing 8-2. Serializing Objects in XML Format

```
private void button1_Click(object sender, EventArgs e)
{
    Employee emp = new Employee();
    emp.EmployeeID = int.Parse(textBox1.Text);
    emp.FirstName = textBox2.Text;
    emp.LastName = textBox3.Text;
    emp.HomePhone = textBox4.Text;
    emp.Notes = textBox5.Text;
```

```

FileStream stream =
    new FileStream($"{Application.StartupPath}\\employee.xml", FileMode.Create);
XmlSerializer serializer = new XmlSerializer(typeof(Employee));
serializer.Serialize(stream, emp);
stream.Close();
if (checkBox1.Checked)
{
    Process.Start($"{Application.StartupPath}\\employee.xml");
}
}

```

The code creates an instance of the Employee class. It then assigns values from various text boxes to the corresponding properties of the Employee class. A FileStream is then created for writing to a physical disk file (Employee.xml). This stream is used while actually serializing the object. Then the code creates an object of the XmlSerializer class. As mentioned previously, the XmlSerializer class allows you to serialize data in XML format.

There are several overloads of the XmlSerializer constructor, and the code uses the one that accepts the type of class whose objects are to be serialized. The type information about the Employee class is obtained by using the typeof keyword. The Serialize() method of XmlSerializer serializes an object to a specified stream, TextWriter, or XmlWriter.

Because our example uses a FileStream to serialize the Employee object, after serialization is complete, the stream is closed. Finally, the serialized data from the XML file is displayed in a browser by using the Start() method of the Process class.

The Click event handler of the Deserialize button contains the code shown in Listing 8-3.

Listing 8-3. Deserializing by Using the XmlSerializer Class

```

private void button2_Click(object sender, EventArgs e)
{
    FileStream stream =
        new FileStream($"{Application.StartupPath}\\employee.xml", FileMode.Open);
    XmlSerializer serializer = new XmlSerializer(typeof(Employee));
    Employee emp = (Employee)serializer.Deserialize(stream);
    stream.Close();
    textBox1.Text = emp.EmployeeID.ToString();
    textBox2.Text = emp.FirstName;
    textBox3.Text = emp.LastName;
    textBox4.Text = emp.HomePhone;
    textBox5.Text = emp.Notes;
}

```

The code creates a FileStream pointing to the same file that was created during the serialization process. Note that this time the file is opened in Open mode and not in Create mode. Then an object of XmlSerializer is created as before.

The Deserialize() method of the XmlSerializer class accepts a Stream, a TextReader, or an XmlReader from which the object is to be read for deserialization. It then returns the deserialized object. The deserialized data is always returned as an object and needs to be casted to the Employee type. Then various property values of the deserialized object are assigned to respective text boxes.

To test the application, you run it, enter some values in the text boxes, and click the Serialize button. Figure 8-2 shows a sample XML document obtained by running the preceding application.

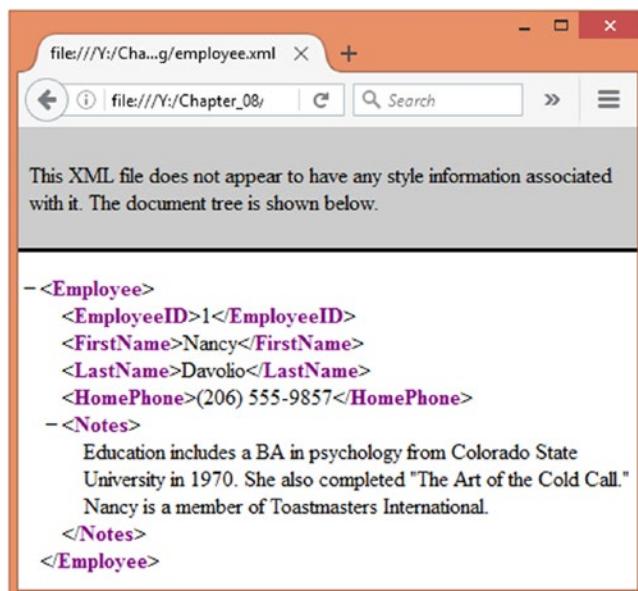


Figure 8-2. Employee object serialized as an XML document

Examine the resultant XML markup carefully. The class name (`Employee`) has become the name of the root element. The elements such as `<EmployeeID>`, `<FirstName>`, and `<LastName>` have the same name as the corresponding properties of the `Employee` class. Now close the application and run it again. This time click the Deserialize button. You will find that the text boxes show the property values that you specified during the last run of the application.

Handling Events Raised During Deserialization

Imagine a case where one application is serializing objects and the other is deserializing them. What if the serialized objects contain some extra attributes and elements? The application that is deserializing such objects must have some way to signal this discrepancy. Fortunately, the `XmlSerializer` class comes with certain events to handle such situations. These events are raised during the deserialization process when the structure of the class and the serialized XML don't match. Table 8-1 lists these events.

Table 8-1. Events of the *XmlSerializer* Class

Event Name	Description
UnknownAttribute	This event is raised when the data being deserialized contains some unexpected attribute. The event receives an event argument of type <i>XmlAttributeEventArgs</i> that supplies more information about the event.
UnknownElement	This event is raised when the data being deserialized contains some unexpected element. The event receives an event argument of type <i>XmlElementEventArgs</i> that supplies more information about the event.
UnknownNode	This event is raised when the data being deserialized contains some unexpected node. The event receives an event argument of type <i>XmlNodeEventArgs</i> that supplies more information about the event.
UnreferencedObject	This event is raised when the data being deserialized contains some recognized type that is not used or is unreferenced. The event receives an event argument of type <i>UnreferencedEventArgs</i> that supplies more information about the event. This event applies only to SOAP-encoded XML.

To illustrate the use of these events, you need to modify the previous application to the one shown in Listing 8-4.

Listing 8-4. Events of the *XmlSerializer* Class

```
private void button2_Click(object sender, EventArgs e)
{
    FileStream stream =
        new FileStream($"{Application.StartupPath}\\employee.xml", FileMode.Open);
    XmlSerializer serializer = new XmlSerializer(typeof(Employee));
    serializer.UnknownAttribute +=
        new XmlAttributeEventHandler(serializer_UnknownAttribute);
    serializer.UnknownElement +=
        new XElementEventHandler(serializer_UnknownElement);
    serializer.UnknownNode += new XmlNodeEventHandler(serializer_UnknownNode);
    Employee emp = (Employee)serializer.Deserialize(stream);
    stream.Close();
    textBox1.Text = emp.EmployeeID.ToString();
    textBox2.Text = emp.FirstName;
    textBox3.Text = emp.LastName;
    textBox4.Text = emp.HomePhone;
    textBox5.Text = emp.Notes;
}

void serializer_UnknownNode(object sender, XmlNodeEventArgs e)
{
    MessageBox.Show($"Unknown Node {e.Name} found at Line {e.LineNumber}");
}
void serializer_UnknownElement(object sender, XElementEventArgs e)
{
    MessageBox.Show($"Unknown Element {e.Element.Name} found at Line {e.LineNumber}");
}
```

```
void serializer_UnknownAttribute(object sender, XmlAttributeEventArgs e)
{
    MessageBox.Show($"Unknown Attribute {e.Attr.Name} found at Line {e.LineNumber}");
}
```

Notice the code marked in bold. After declaring the instance of the `XmlSerializer` class, it wires up three event handlers—`UnknownAttribute`, `UnknownElement`, and `UnknownNode`—that simply display a message box showing the name of the attribute, element, or node and the line number at which the attribute, element, or node is encountered. Notice how the event argument parameter is used to extract information about the unexpected content.

To test these events, modify the serialized XML file manually, as shown in Listing 8-5.

Listing 8-5. Modifying the Serialized XML Manually

```
<?xml version="1.0"?>
<Employee xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema" EmpCode="E001"OfficePhoneOfficePhone

```

Notice the markup in bold. We added an `EmpCode` attribute and an `<OfficePhone>` element manually to the XML file. Save the file and run the application. This time when you click the `Deserialize` button, you will see message boxes informing you of the discrepancies. Figure 8-3 shows one such message box.

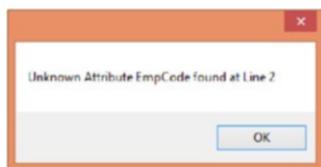


Figure 8-3. Unexpected content encountered during the deserialization process

Serializing and Deserializing Complex Types

In the preceding example, we serialized simple types; the members of the `Employee` class were simple types such as an integer and a string. However, real-world classes are often complex ones. They may contain members that are class types, enumerated types, or even arrays. The `XmlSerializer` class provides support for such complex types, and that is what you are going to see in the next example.

The user interface of the application now changes to look like the one shown in Figure 8-4.

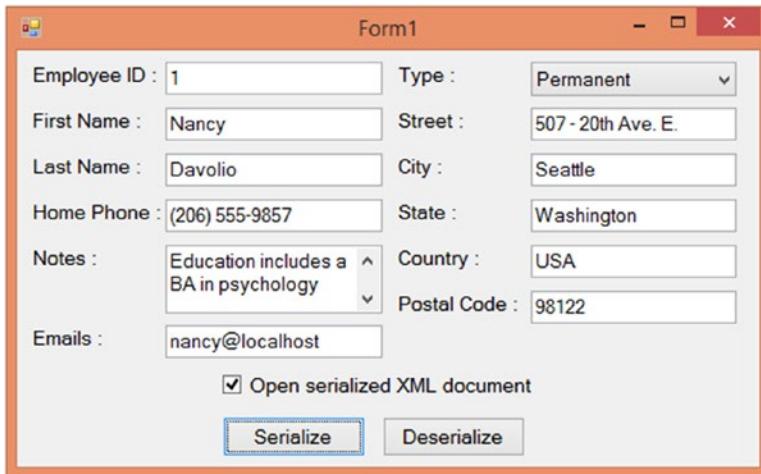


Figure 8-4. Application for illustrating XML serialization of complex types

The first five text boxes remain the same as in the previous example. However, six text boxes and one combo box are new. The newly added text boxes capture the e-mail, street, city, state, country, and postal code information of the employee. The combo box captures the employee type (permanent or contract).

To store the address information of employees, you need to add a property called Address to the Employee class. The Address property itself is of type Address. The Address class is shown in Listing 8-6.

Listing 8-6. The Address Class

```
public class Address
{
    public string Street { get; set; }
    public string City { get; set; }
    public string State { get; set; }
    public string Country { get; set; }
    public string PostalCode { get; set; }
}
```

This class has five public properties for storing street address, city, state, country, and postal code, respectively.

To store the employee type, you need to add a property called Type to the Employee class. The Type property will be an enumeration of type EmployeeType, which contains two values: Permanent and Contract. The EmployeeType enumeration is shown in Listing 8-7.

Listing 8-7. The EmployeeType Enumeration

```
public enum EmployeeType
{
    Permanent, Contract
}
```

The e-mail information is stored in a property called Emails. An employee can have more than one e-mail address and hence this property is of the string array type. Listing 8-8 shows the modified version of the Employee class.

Listing 8-8. The Employee Class After Adding Address, Type, and Emails Properties

```
public class Employee
{
    public int EmployeeID { get; set; }
    public string FirstName { get; set; }
    public string LastName { get; set; }
    public string HomePhone { get; set; }
    public string Notes { get; set; }
    public string[] Emails { get; set; }
    public EmployeeType Type { get; set; }
    public Address Address { get; set; } = new Address();
}
```

Notice the property definitions marked in bold. The three public properties—Address, Type, and Emails—are of type Address, EmployeeType, and string array, respectively. The code in the Click event handler of the Serialize button now changes to the code shown in Listing 8-9.

Listing 8-9. Serializing Complex Types

```
private void button1_Click(object sender, EventArgs e)
{
    Employee emp = new Employee();
    emp.EmployeeID = int.Parse(textBox1.Text);
    emp.FirstName = textBox2.Text;
    emp.LastName = textBox3.Text;
    emp.HomePhone = textBox4.Text;
    emp.Notes = textBox5.Text;
    emp.Type =
        (comboBox1.SelectedIndex == 0 ? EmployeeType.Permanent :
        EmployeeType.Contract);
    emp.Address.Street = textBox6.Text;
    emp.Address.City = textBox7.Text;
    emp.Address.State = textBox8.Text;
    emp.Address.Country = textBox9.Text;
    emp.Address.PostalCode = textBox10.Text;
    emp.Emails = textBox11.Text.Split(',');
    FileStream stream =
        new FileStream($"{Application.StartupPath}\\employee.xml", FileMode.Create);
    XmlSerializer serializer = new XmlSerializer(typeof(Employee));
    serializer.Serialize(stream, emp);
    stream.Close();
    if (checkBox1.Checked)
    {
        Process.Start($"{Application.StartupPath}\\employee.xml");
    }
}
```

The code is essentially the same as in the preceding examples. However, it sets the newly added properties to corresponding values from the text boxes and combo box. Notice how the complex property Address is set. Also, notice how comma-separated emails entered in the e-mail text box are converted into a string array by using the Split() method. After the Employee object is serialized by calling Serialize(), the serialized XML document looks like the one shown in Figure 8-5.

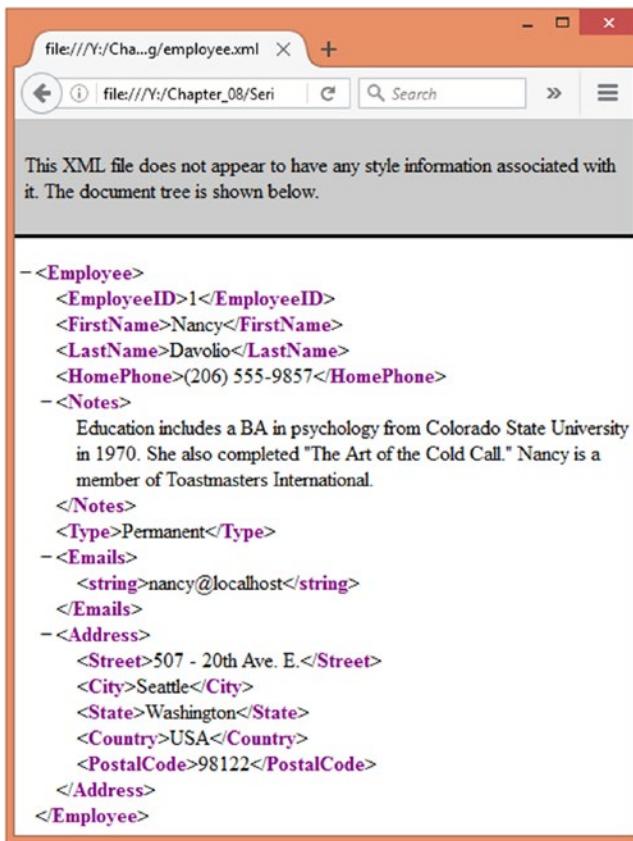


Figure 8-5. Serialized XML for complex types

Examine the serialized XML data carefully. The address is represented by the `<Address>` node, the name of which is derived from the `Address` property of the `Employee` class. The `<Address>` node has five child nodes: `<Street>`, `<City>`, `<State>`, `<Country>`, and `<PostalCode>`. Their names are derived from the respective properties of the `Address` class.

The `<Type>` element represents the `Type` property of the `Employee` class. The enumeration value, `Permanent`, is stored in the XML markup. Finally, the `<Emails>` node represents the `Emails` property, and its child nodes are nothing but individual array elements. Because the e-mails are stored in a string array, the individual values are enclosed in `<string></string>` elements.

Listing 8-10 shows the code in the Click event of the Deserialize button.

Listing 8-10. Deserializing Complex Types

```

private void button2_Click(object sender, EventArgs e)
{
    FileStream stream = new FileStream($"{Application.StartupPath}\\employee.xml", FileMode.Open);
    XmlSerializer serializer = new XmlSerializer(typeof(Employee));
    Employee emp=(Employee)serializer.Deserialize(stream);
    stream.Close();
    textBox1.Text = emp.EmployeeID.ToString();
}

```

```

    textBox2.Text = emp.FirstName;
    textBox3.Text = emp.LastName;
    textBox4.Text = emp.HomePhone;
    textBox5.Text = emp.Notes;
    comboBox1.SelectedIndex = (emp.Type == EmployeeType.Permanent?0:1);
    textBox6.Text=emp.Address.Street;
    textBox7.Text=emp.Address.City;
    textBox8.Text=emp.Address.State;
    textBox9.Text=emp.Address.Country;
    textBox10.Text=emp.Address.PostalCode;
    textBox11.Text = string.Join(", ", emp.Emails);
    stream.Close();
}

```

The code is very much the same as in previous examples. It deserializes the previously serialized `Employee` object by using the `XmlSerializer` class. The property values are then assigned to various controls on the form. Notice how the `Emails` property is converted into a comma-separated string by using the `Join()` method of the `string` class. The following points are worth noting when serializing complex types:

- To serialize and deserialize enumerated values, the application that serializes the object and the application that deserializes it must define the same enumeration under consideration.
- While serializing object properties, all the public members of the object are serialized. The member names are assigned to the child elements in the resultant XML.
- During the deserialization process, `XmlSerializer` instantiates the main class (`Employee`) as well as all the subclasses (`Address`) and assigns values to the respective properties.
- While serializing arrays, an XML element represents the array. The individual array elements form the child element of this element. The individual array elements are enclosed in an element depending on the data type of the array.
- While deserializing, `XmlSerializer` creates an array with the same number of elements as the serialized elements. It then assigns the array element values accordingly.

Serialization and Inheritance

Serialization is not limited to simple and complex types. It is equally applicable to inherited classes. Assume that you have a class called `Manager` that inherits from our `Employee` class. Now when you serialize `Manager`, all the public properties of the `Employee` base class and `Manager` are serialized. This is also true in the case of a long chain of inheritance.

To demonstrate how inherited classes are serialized, we need to add a class called `Manager` to our application. The `Manager` class inherits from the `Employee` class (see Listing 8-1) and extends it by adding an integer property `NoOfSubordinates`. The `Manager` class is shown in Listing 8-11.

Listing 8-11. The Manager Class

```
public class Manager : Employee
{
    public int NoOfSubordinates { get; set; }
}
```

The code creates a class named Manager that inherits from the Employee class. It then adds an integer property—NoOfSubordinates—to store the number of subordinates of a manager. To accommodate the additional property, the user interface of the application changes, as shown in Figure 8-6.

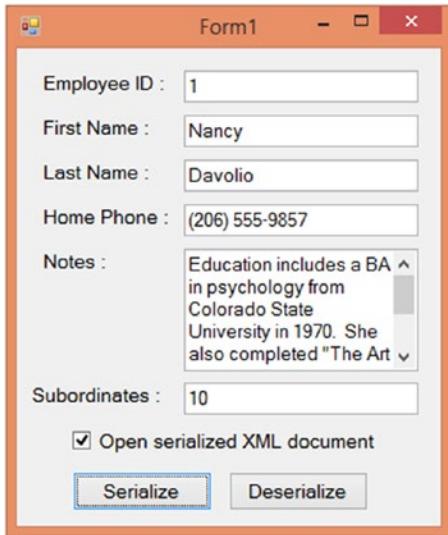


Figure 8-6. Application to demonstrate serialization of inherited classes

The application is almost the same as in Figure 8-1, but there is an extra text box for accepting the number of subordinates of the manager. Listing 8-12 shows the Click event handler of the Serialize button.

Listing 8-12. Serializing the Inherited Manager Class

```
private void button1_Click(object sender, EventArgs e)
{
    Manager manager = new Manager();
    manager.EmployeeID = int.Parse(textBox1.Text);
    manager.FirstName = textBox2.Text;
    manager.LastName = textBox3.Text;
    manager.HomePhone = textBox4.Text;
    manager.Notes = textBox5.Text;
    manager.NoOfSubordinates = int.Parse(textBox6.Text);
    FileStream stream =
        new FileStream($"{Application.StartupPath}\\employee.xml", FileMode.Create);
    XmlSerializer serializer = new XmlSerializer(typeof(Manager));
    serializer.Serialize(stream, manager);
    stream.Close();
}
```

```

if (checkBox1.Checked)
{
    Process.Start($"{Application.StartupPath}\\employee.xml");
}
}

```

The code is essentially the same as we have been using up until now, but it uses the Manager class instead of the Employee class. An instance of Manager is created, and all its properties are set. Then an instance of `XmlSerializer` is created by passing the Type information of the Manager class. Finally, the Manager instance is serialized by calling the `Serialize()` method of `XmlSerializer`. Figure 8-7 shows the resultant XML output.

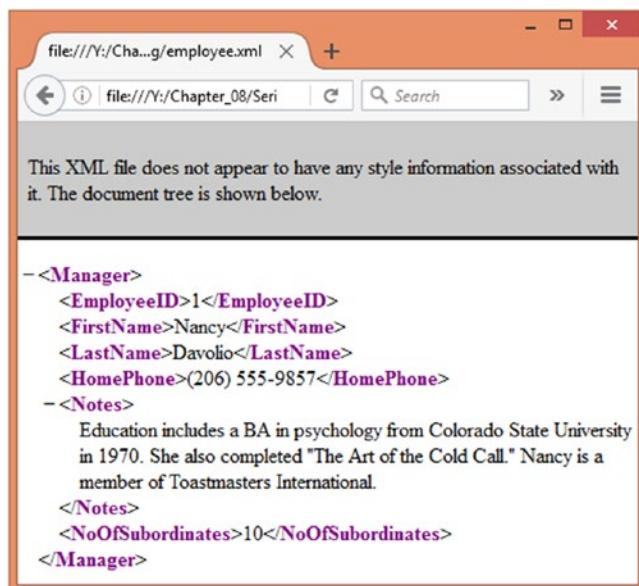


Figure 8-7. Serialized XML of the Manager class

Notice how all the public properties from the Employee base class as well as the one from Manager are serialized. The code to deserialize the Manager class is very similar to the one we used previously. Listing 8-13 shows this code.

Listing 8-13. Deserializing the Manager Class

```

private void button2_Click(object sender, EventArgs e)
{
    FileStream stream =
        new FileStream($"{Application.StartupPath}\\employee.xml", FileMode.Open);
    XmlSerializer serializer = new XmlSerializer(typeof(Manager));
    Manager manager = (Manager)serializer.Deserialize(stream);
    stream.Close();
    textBox1.Text = manager.EmployeeID.ToString();
    textBox2.Text = manager.FirstName;
    textBox3.Text = manager.LastName;
}

```

```

    textBox4.Text = manager.HomePhone;
    textBox5.Text = manager.Notes;
    textBox6.Text = manager.NoOfSubordinates.ToString();
}

```

The only difference in this code is that it uses Manager in the deserialization process instead of Employee.

Customizing the Serialized XML

The `XmlSerializer` class automatically uses the name of the public members as the names for the resultant XML elements. This is what is required in many cases. However, sometimes you may need to customize the serialized XML data to suit your needs. In the previous example illustrating the serialization of complex types, we got the XML document shown in Listing 8-14.

Listing 8-14. Serialized XML Document Without Any Customization

```

<?xml version="1.0"?>
<Employee xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <EmployeeID>1</EmployeeID>
  <FirstName>Nancy</FirstName>
  <LastName>Davolio</LastName>
  <HomePhone>(206) 555-9857</HomePhone>
  <Notes>Education includes a BA in psychology from Colorado State University in 1970.
  She also completed "The Art of the Cold Call." Nancy is a member of Toastmasters
  International.</Notes>
  <Type>Permanent</Type>
  <Emails>
    <string>nancy@localhost</string>
  </Emails>
  <Address>
    <Street>507 - 20th Ave. E. Apt. 2A</Street>
    <City>Seattle</City>
    <State>Washington</State>
    <Country>USA</Country>
    <PostalCode>98122</PostalCode>
  </Address>
</Employee>

```

However, what if you want the resultant XML structure to resemble Listing 8-15?

Listing 8-15. Serialized XML After Customization

```

<?xml version="1.0"?>
<MyEmployee xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema" EmployeeCode="1">
  <FName>Nancy</FName>
  <LName>Davolio</LName>

```

```

<Remarks>
Education includes a BA in psychology from Colorado State University in 1970. She also
completed "The Art of the Cold Call." Nancy is a member of Toastmasters International.
</Remarks>
<EmployeeType>Permanent Employee</EmployeeType>
<EmailAddresses>
  <Email>nancy@localhost</Email>
</EmailAddresses>
<Address>
  <Street>507 - 20th Ave. E. Apt. 2A</Street>
  <City>Seattle</City>
  <State>Washington</State>
  <Country>USA</Country>
  <PostalCode>98122</PostalCode>
</Address>
</MyEmployee>

```

Observe Listing 8-15 carefully. There are some significant changes:

- The root element of the document is `<MyEmployee>` and not `<Employee>`.
- The element names are totally different from the public property names.
- The employee ID is stored as the `EmployeeCode` attribute.
- The `EmployeeType` enumeration value is different from the actual enumeration item text.
- E-mail addresses are stored as `<Email>` elements and not as `<string>` elements.
- The `HomePhone` property value is not serialized even if it is a public member of the class.

To achieve such customization, the `System.Xml.Serialization` namespace provides several attributes. You are required to decorate your classes, enumerations, and properties with these attributes to customize the way they are serialized. Listing 8-16 shows the `Employee` class and the `EmployeeType` enumeration after applying many of these attributes.

Listing 8-16. Customizing Serialization by Using Attributes

```

[XmlAttribute(ElementName = "EmployeeCode")]
public class Employee
{
  [XmlAttribute(AttributeName = "EmployeeCode")]
  public int EmployeeID { get; set; }

  [XmlElement(ElementName = "FName")]
  public string FirstName { get; set; }

  [XmlElement(ElementName = "LName")]
  public string LastName { get; set; }

  [XmlIgnore]
  public string HomePhone { get; set; }
}

```

```

[XmlElement(ElementName = "Remarks")]
public string Notes { get; set; }

[XmlArray(ElementName = "EmailAddresses")]
    [XmlArrayItem(ElementName = "Email")]
public string[] Emails { get; set; }

[XmlElement(ElementName = "EmployeeType")]
public EmployeeType Type { get; set; }

[XmlElement(IsNullable = true)]
public Address Address { get; set; } = new Address();
}

public enum EmployeeType
{
    [XmlAttribute(Name="Permanent Employee")]
    Permanent,
    [XmlAttribute(Name = "Employee on contract")]
    Contract
}

```

Let's dissect the preceding listing step by step and see the significance of each attribute used.

Changing the XML Document Root

By default, the `XmlSerializer` class uses the name of the class as the name of the XML root element. To alter this behavior, you can decorate your class with the `[XmlRoot]` attribute. The `[XmlRoot]` attribute has a property called `ElementName` that indicates the new name of the XML document root element. The `[XmlRoot]` attribute must be applied to a class definition and hence we've placed it on top of the `Employee` class.

Changing the Element Names

By default, the `XmlSerializer` class uses the names of the public members to assign to the output XML elements. For example, the `FirstName` property gets serialized as the `<FirstName>` element. This default behavior can be altered by using the `[XmlElement]` attribute. The `[XmlElement]` attribute has a property called `ElementName` that specifies the name of the resulting XML element. The `[XmlElement]` attribute is applied to the public member that will be serialized, and thus the `FirstName`, `LastName`, `Notes`, `Type`, and `Address` properties are decorated with the `[XmlElement]` attribute.

Serializing Members As Attributes

By default, all the public members of your class are serialized as XML elements in the output document. The `[XmlAttribute]` attribute allows you to change this default behavior. The `AttributeName` property of the `[XmlAttribute]` attribute indicates the name that will be given to the resultant XML attribute. `[XmlAttribute]` is applied to the public member that you want to serialize as an attribute. In our example, we add the `[XmlAttribute]` attribute to the `EmployeeID` property.

Ignoring Public Members in the Serialization Process

By default, all the public members of a class are serialized, but sometimes this is not what you want. For example, if you are storing credit card information in a public property, you may not want to serialize it for obvious security reasons. A public member can be ignored during the serialization process by decorating it with the `[XmlAttribute]` attribute. In our example, the `HomePhone` property is marked with this attribute.

Changing Array and Array Element Names

The `Employee` class has a property called `Emails` that is of type string array. Under the default naming scheme, when this property is serialized, an XML node is created with the name `Emails`. This node further contains child nodes, each containing the array element value. The names of the child elements are the same as the data type of the array (`<string>` in our example). You can alter this behavior with the help of the `[XmlArray]` and `[XmlElement]` attributes. The former marks public members that are array types and specifies the XML element name for the member. The latter attribute governs the name of the XML element assigned to the individual array members. In our example, the `Emails` property will be serialized as `<EmailAddresses>`, and each array element will be enclosed within an `<Email>` element.

Ignoring Null Objects in the Serialization Process

The `Employee` class has an `Address` property that is an object type. If this property is null, `XmlSerializer` still emits an empty XML element for it, but you can use the `[XmlElement]` attribute to change this behavior. The `IsNullable` Boolean property of the `[XmlElement]` attribute indicates whether the empty XML element will be emitted when the member is null. Setting this property to `true` will not emit the empty XML element if the `Address` property is null.

Changing Enumeration Identifiers

The `EmployeeType` enumeration has two values: `Permanent` and `Contract`. By default when a member of the `EmployeeType` type is serialized, the value of these enumeration identifiers is emitted in the serialized XML. The `[XmlEnum]` attribute specifies the alternate value to serialize instead of the actual identifier name, and is applied on enumeration identifiers. The `Name` property of the `[XmlEnum]` attribute specifies the text that will be serialized instead of the identifier name.

Serializing and Deserializing Objects Using DataContractSerializer

In the preceding section, you used the `XmlSerializer` class to serialize and deserialize objects. The `XmlSerializer` has been available since version 1.1 of the .NET Framework. Along with Windows Communication Foundation (WCF) another class, called `DataContractSerializer`, was added that can also be used for XML serialization. The `DataContractSerializer` class is the default serializer for WCF services, but you can also use it to serialize and deserialize your objects as you did with the `XmlSerializer`.

In order to use `DataContractSerializer`, you need to add a couple of attributes to your classes:

- The class must be decorated with the `[DataContract]` attribute.
- Every member of the class that you want to be serialized must be marked with `[DataMember]` attribute. Members not decorated with `[DataMember]` will be ignored during the serialization process.

Note We are going to revisit the [DataContract] and [DataMember] attributes in Chapter 10 when we discuss WCF services. At that time, it will be more clear to you as to how these attributes are used by WCF. Here it suffices to say that they are necessary to serialize an object using the DataContractSerializer class.

To illustrate the use of DataContractSerializer class, you will develop a similar application as for XmlSerializer (see Figure 8-1). Of course, you will need to modify the Employee class and the code that serializes and deserializes the Employee object, as discussed next.

First of all, open the Employee class and modify it, as shown in Listing 8-17.

Listing 8-17. Marking a Class with the [DataContract] and [DataMember] Attributes

```
[DataContract]
public class Employee
{
    [DataMember]
    public int EmployeeID { get; set; }
    [DataMember]
    public string FirstName { get; set; }
    [DataMember]
    public string LastName { get; set; }
    [DataMember]
    public string HomePhone { get; set; }
    [DataMember]
    public string Notes { get; set; }
}
```

The [DataContract] attribute added to the Employee class indicates that the Employee class is a data contract and can be serialized by DataContractSerializer. The [DataMember] attribute added to the properties of Employee class indicates that the member under consideration is part of a data contract and can be serialized by the DataContractSerializer.

Next, modify the Click event handler of the Serialize button, as shown in Listing 8-18.

Listing 8-18. Serialize Data Using DataContractSerializer

```
private void button1_Click(object sender, EventArgs e)
{
    Employee emp = new Employee();
    emp.EmployeeID = int.Parse(textBox1.Text);
    emp.FirstName = textBox2.Text;
    emp.LastName = textBox3.Text;
    emp.HomePhone = textBox4.Text;
    emp.Notes = textBox5.Text;
    FileStream stream = new FileStream($"{Application.StartupPath}\\employee.xml", FileMode.Create);

    DataContractSerializer serializer = new DataContractSerializer(typeof(Employee));
    serializer.WriteObject(stream, emp);
```

```

        stream.Close();
        if (checkBox1.Checked)
        {
            Process.Start($"{Application.StartupPath}\\\\employee.xml");
        }
    }
}

```

Most of the code shown in Listing 8-18 should look familiar to you except the lines marked in bold. The first line marked in bold creates an instance of `DataContractSerializer` by passing the type information of the `Employee` class. The second line calls the `WriteObject()` method of `DataContractSerializer`. The `WriteObject()` method accepts two parameters—a stream object to write the data and the object to be serialized.

If you run the application and click on the Serialize button after filling various text boxes, the resultant XML document should resemble Figure 8-8.

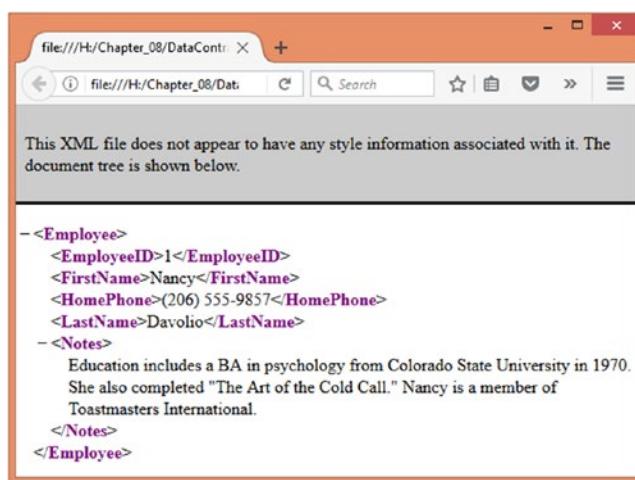


Figure 8-8. XML serialized by `DataContractSerializer`

In order to deserialize XML previously serialized using `DataContractSerializer`, you can use the `ReadObject()` method. Listing 8-19 shows the Click event handler of the Deserialize button that illustrates the use of `ReadObject()`.

Listing 8-19. Serialize Data Using `DataContractSerializer`

```

private void button2_Click(object sender, EventArgs e)
{
    FileStream stream = new FileStream($"{Application.StartupPath}\\\\employee.xml",
        FileMode.Open);

    DataContractSerializer serializer = new DataContractSerializer(typeof(Employee));
    Employee emp = (Employee)serializer.ReadObject(stream);

    stream.Close();
    textBox1.Text = emp.EmployeeID.ToString();
    textBox2.Text = emp.FirstName;
}

```

```

    textBox3.Text = emp.LastName;
    textBox4.Text = emp.HomePhone;
    textBox5.Text = emp.Notes;
}

```

Notice the code marked in bold. The first line creates an instance of `DataContractSerializer` by passing the type information of `Employee` class. The second line then calls the `ReadObject()` method on the `DataContractSerializer`. The stream to read is supplied as the parameter to `ReadObject()`. The `ReadObject()` reads an object, which is then casted to the `Employee` type.

If you run the application again and click on the `Deserialize` button, you will find that all the text boxes are filled with the correct values.

Customizing the Serialized XML

As you must have observed, the `DataContractSerializer` uses the class name and property names by default for the resultant XML elements. You can customize the XML element names by specifying them in the `[DataContract]` and `[DataMember]` attributes. Listing 8-20 shows how this is done.

Listing 8-20. Customizing XML Element Names

```

[DataContract(Name ="MyEmployee")]
public class Employee
{
    [DataMember(Name ="EmployeeCode")]
    public int EmployeeID { get; set; }
    [DataMember(Name = "FName")]
    public string FirstName { get; set; }
    [DataMember(Name = "LName")]
    public string LastName { get; set; }
    [IgnoreDataMember]
    public string HomePhone { get; set; }
    [DataMember(Name = "Remarks")]
    public string Notes { get; set; }
}

```

The `[DataContract]` attribute now specifies its `Name` property to be `MyEmployee`. Thus the root element name will be `MyEmployee`. The `[DataMember]` attributes added to the `EmployeeID`, `FirstName`, `LastName` and `Notes` properties set their `Name` properties to `EmployeeCode`, `FName`, `LName`, and `Remarks`, respectively. The `HomePhone` property is decorated with the `[IgnoreDataMember]` attribute, indicating that `HomePhone` won't be serialized.

Figure 8-9 shows a sample XML generated after the customization just discussed.

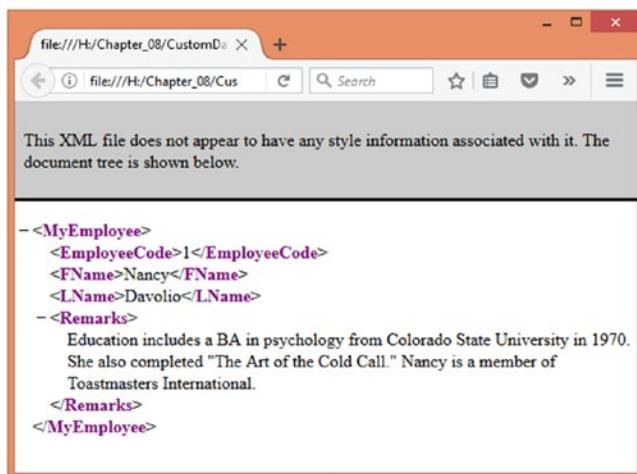


Figure 8-9. XML element names are now customized

As you can see, the XML element names are now as per our `Name` property. Also, the `HomePhone` has not been serialized. If you deserialize this XML, you will find that all the text boxes except `HomePhone` are populated as expected. The `HomePhone` text box remains empty for obvious reasons.

Serializing and Deserializing Objects Using SoapFormatter

In the beginning of this chapter, you learned that there are three flavors of serialization based on the format (binary, XML, and SOAP). Serializing objects into binary format is outside the scope of this book, and you have already learned how to serialize objects in XML format using the `XmlSerializer` and `DataContractSerializer` classes. Now it's time to learn how objects can be serialized in SOAP format using the `SoapFormatter` class.

Note The `SoapFormatter` class used in this section is now considered obsolete. We discuss it here because some older applications might still be using it. Also, it gives you chance to become familiar with the SOAP format without going into the details of ASMX web services or WCF services.

SOAP is an industry standard that forms one of the pillars of web services. Though SOAP is used extensively along with web services, you can use it as an encoding format for object serialization.

When you serialize objects by using the `XmlSerializer` class, you need not do anything special to the classes themselves. However, when you want to use SOAP as a serialization format, you must mark your classes with the `[Serializable]` attribute. Only then can your classes be serialized.

The `SoapFormatter` class takes care of all the intricacies of serializing your objects in SOAP format. The `SoapFormatter` class resides in the `System.Runtime.Serialization.Formatters.Soap` namespace, which physically resides in the `System.Runtime.Serialization.Formatters.Soap.dll` assembly.

Let's revisit the application that we developed when we began this chapter (see Figure 8-1) and modify it to use `SoapFormatter` instead of `XmlSerializer`. The user interface of the application remains unchanged, but the way we serialize and deserialize the objects differs.

First, you need to mark the `Employee` class with the `[Serializable]` attribute. The modified `Employee` class is shown in Listing 8-21.

Listing 8-21. Marking a Class with the [Serializable] Attribute

```
[Serializable]
public class Employee
{
    public int EmployeeID { get; set; }
    public string FirstName { get; set; }
    public string LastName { get; set; }
    public string HomePhone { get; set; }
    public string Notes { get; set; }
}
```

As you can see, the [Serializable] attribute is a class-level attribute. Hence it is placed on the top of the Employee class and marked as a serializable class. Listing 8-22 shows the Click event handler of the Serialize button. This time the code uses the SoapFormatter class.

Listing 8-22. Serializing Objects by Using the SoapFormatter Class

```
private void button1_Click(object sender, EventArgs e)
{
    Employee emp = new Employee();
    emp.EmployeeID = int.Parse(textBox1.Text);
    emp.FirstName = textBox2.Text;
    emp.LastName = textBox3.Text;
    emp.HomePhone = textBox4.Text;
    emp.Notes = textBox5.Text;
    FileStream stream =
        new FileStream($"{Application.StartupPath}\\employee.xml", FileMode.Create);

    SoapFormatter formatter = new SoapFormatter();
    formatter.Serialize(stream, emp);
    stream.Close();
    if (checkBox1.Checked)
    {
        Process.Start($"{Application.StartupPath}\\employee.xml");
    }
}
```

The code creates an instance of the Employee class and sets its properties to the values entered in the text boxes. A FileStream object is then created and creates a file to which the serialized data is to be written. Then a SoapFormatter object is created. The Serialize() method of SoapFormatter accepts two parameters: a stream to which the serialized data is to be written and the object that is to be serialized. The counterpart of this operation is performed in the Click event handler of the Deserialize button and is shown in Listing 8-23.

Listing 8-23. Deserialization by Using the SoapFormatter Class

```
private void button2_Click(object sender, EventArgs e)
{
    FileStream stream =
        new FileStream($"{Application.StartupPath}\\employee.xml", FileMode.Open);
    SoapFormatter formatter = new SoapFormatter();
    Employee emp=(Employee)formatter.Deserialize(stream);
    textBox1.Text = emp.EmployeeID.ToString();
    textBox2.Text = emp.FirstName;
    textBox3.Text = emp.LastName;
    textBox4.Text = emp.HomePhone;
    textBox5.Text = emp.Notes;
    stream.Close();
}
```

The code opens a stream pointing to the same file to which the object was serialized before. An instance of `SoapFormatter` is then created. The `Deserialize()` method of `SoapFormatter` reads the stream and deserializes the object. The return value of `Deserialize()` is of type `object` and hence it is type converted to the `Employee` class. After the `Employee` object is retrieved, its property values are assigned to the corresponding text boxes. If you run the application and serialize the `Employee` object, you should see output similar to Figure 8-10.

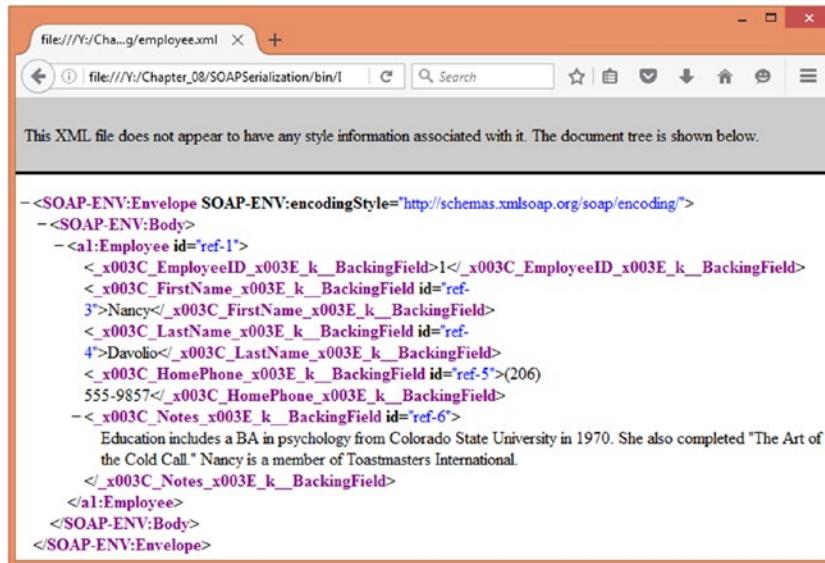


Figure 8-10. Object serialized in SOAP format

As you can see, the XML output is now in SOAP format. There is also mention of some namespaces related to SOAP. Notice that the XML element names are not same as the property names, instead unique element names are formed using the property names. Unlike XML serialization, which is shallow by nature, SOAP serialization done via the `SoapFormatter` class is deep serialization. It serializes private, protected, and public members of an object.

Customizing SOAP Serialization

In the preceding section, you used the default behavior of SOAP serialization to serialize and deserialize objects. You can also customize the SOAP serialization process if you want. There are two ways to achieve this:

- Implement the `ISerializable` interface.
- Use certain serialization and deserialization attributes.

The first method has been available since .NET Framework 1.1. The latter method was introduced in .NET 2.0. In our example, we are going to use both the methods to customize the serialization process.

We will use the same application that we developed in the previous section while illustrating the use of the `SoapFormatter` class. Suppose that you want to customize the names of the elements in the resultant SOAP message. You also want to control which properties are being serialized.

Finally, also suppose that you want to protect the serialized XML data from casual users. You want to implement Base64 encoding to the data that is being serialized so that casual readers cannot easily read the file content. That data needs to be encoded in a Base64 encoding scheme and decoded when deserialized.

Open the `Employee` class you created earlier and implement the `ISerializable` interface on it. As a part of the implementation, you need to do two things:

- Implement the `GetObjectData()` method.
- Add a constructor that handles deserialization.

Listing 8-24. `GetObjectData()` Added to Employee Class

```
public void GetObjectData(SerializationInfo info, StreamingContext context)
{
    info.AddValue("EmpCode", EmployeeID, typeof(int));
    info.AddValue("FName", FirstName, typeof(string));
    info.AddValue("LName", LastName, typeof(string));
    info.AddValue("Remarks", Notes, typeof(string));
}
```

The `GetObjectData()` method has two parameters—`SerializationInfo` and `StreamingContext`. The `GetObjectData()` method is called after you call the `Serialize()` method on the `SoapFormatter` object.

The code inside `GetObjectData()` uses the `AddValue()` method of the `SerializationInfo` object to decide what values will be serialized. For example, the first call to `AddValue()` specifies that `EmployeeID` value will be serialized as an `EmpCode` element. The data type of the value is also specified using the third parameter. Notice that we don't serialize the `HomePhone` property of the `Employee` class. The other properties are serialized as `EmpCode`, `FName`, `LName`, and `Remarks`, respectively.

Next, add a constructor to the `Employee` class that matches the signature shown in Listing 8-25. This constructor will be called when you call the `Deserialize()` method of the `SoapFormatter` object.

Listing 8-25. Constructor That Handles the Deserialization

```
protected Employee(SerializationInfo info, StreamingContext context)
{
    EmployeeID = (int)info.GetValue("EmpCode", typeof(int));
    FirstName = (string)info.GetValue("FName", typeof(string));
    LastName = (string)info.GetValue("LName", typeof(string));
    Notes = (string)info.GetValue("Remarks", typeof(string));
    HomePhone = "";
}
```

The constructor accepts the same two parameters as the `GetObjectData()` method. The purpose of this constructor is to retrieve previously serialized values and assign them to properties.

This is done using the `GetValue()` method of `SerializationInfo` class. The `GetValue()` method accepts the name associated with the value to be retrieved and its data type. Upon retrieving the value it is casted and assigned to the corresponding property of the `Employee` object being constructed. Notice that the `HomePhone` property is assigned an empty string value since we have ignored it during serialization process.

Now add two helper functions called `Encode()` and `Decode()` to the preceding application, as shown in Listing 8-26.

Listing 8-26. Encoding and Decoding Data by Using Base64 Encoding

```
private string Encode(string str)
{
    byte[] data = ASCIIEncoding.ASCII.GetBytes(str);
    return Convert.ToBase64String(data);
}

private string Decode(string str)
{
    byte[] data=Convert.FromBase64String(str);
    return ASCIIEncoding.ASCII.GetString(data);
}
```

Make sure to add these helper methods to the `Employee` class. The `Encode()` function accepts a string that is to be encoded in Base64 format. It then converts the string into a byte array by using the `GetBytes()` method of the `ASCIIEncoding` class. The byte array is then fed to the `ToBase64String()` method of the `Convert` class, which returns a Base64-encoded string representing the supplied array of bytes.

The `Decode()` function accepts a Base64-encoded string that is to be decoded back to a plain string representation. It then calls the `FromBase64String()` method of the `Convert` class and passes the supplied Base64 string to it. The `FromBase64String()` method returns a byte array representing the decoded version of the supplied string. The byte array is converted to a string by using the `GetString()` method of the `ASCIIEncoding` class.

Now we need to add four methods to the `Employee` class, as shown in Listing 8-27.

Listing 8-27. Customizing SOAP Serialization and Deserialization

```
[OnSerializing]
public void OnSerializing(StreamingContext context)
{
    FirstName = Encode(FirstName);
    LastName = Encode(LastName);
    HomePhone = Encode(HomePhone);
    Notes = Encode(Notes);
}

[OnSerialized]
public void OnSerialized(StreamingContext context)
{
    FirstName = Decode(FirstName);
    LastName = Decode(LastName);
    HomePhone = Decode(HomePhone);
    Notes = Decode(Notes);
}
```

```
[OnDeserializing]
public void OnDeserializing(StreamingContext context)
{
    //no code here
}

[OnDeserialized]
public void OnDeserialized(StreamingContext context)
{
    FirstName = Decode(FirstName);
    LastName = Decode(LastName);
    HomePhone = Decode(HomePhone);
    Notes = Decode(Notes);
}
```

The four methods are marked with the [OnSerializing], [OnSerialized], [OnDeserializing], and [OnDeserialized] attributes. These attributes allow you to customize the serialization and deserialization process by using pre- and post-methods:

- The method marked with [OnSerializing] is automatically called by the serialization framework before the data is serialized.
- The method marked with [OnSerialized] is called when the serialization is complete.
- Similarly, the methods marked with [OnDeserializing] and [OnDeserialized] are called before and after the deserialization operation.

All these methods must accept a parameter of type `StreamingContext`. The `StreamingContext` parameter provides additional information about the serialization or deserialization process.

In our example, the `OnSerializing()` method calls the `Encode()` helper method that we created earlier to encode the property values into Base64 format. Thus the data being serialized is not a plain string but a Base64 string. After the serialization is complete, we may still need the same data in plain-string format. That is why the `Decode()` method is called in the `OnSerialized()` method.

The `OnDeserializing()` method doesn't include any code in our example. However, if you want to execute some code before deserialization takes place, you can add your custom logic in this method. After the previously serialized data is deserialized, it should give us the values in plain-string format and not in Base64 format. Hence the `OnDeserialized()` method calls `Decode()` and converts the Base64 values into plain text. Figure 8-11 shows a sample SOAP data post serialization.

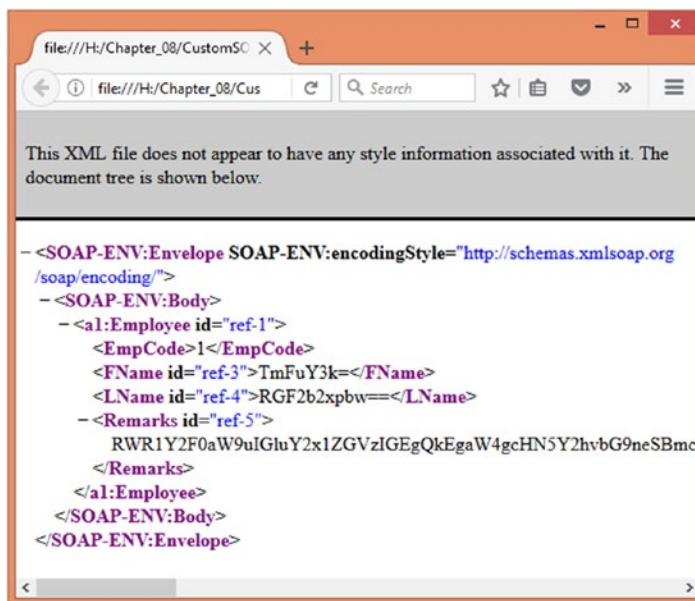


Figure 8-11. Base64-encoded data after serialization

Notice how the entire data is serialized in Base64 format. Also notice how element names are picked from the values specified in the `GetObjectData()` method.

If you click on the Deserialize button, you will find that all the text boxes except HomePhone are populated with correct values. This is because we ignored HomePhone during the serialization.

Summary

In this chapter, we examined the XML serialization process in detail. The .NET Framework itself uses serialization in many places including web services and WCF services. The three classes, namely `XmlSerializer`, `DataContractSerializer`, and `SoapFormatter`, allow you to serialize your objects in XML and SOAP. The `XmlSerializer` is used by XML web services to perform the serialization. `DataContractSerializer` is used by WCF services and Web API to perform the serialization.

The XML serialization done using `XmlSerializer` can be customized with the help of various attributes such as `[XmlRoot]` and `[XmlElement]`. The XML serialization done using `DataContractSerializer` can be customized with the help of attributes such as `[DataContract]` and `[DataMember]`. The SOAP serialization done using `SoapFormatter` can be customized by implementing the `ISerializable` interface. You can also use attributes such as `[OnSerializing]` and `[OnDeserialized]` to control the pre- and post-processing of the data.

In the next chapter, you are going to learn about XML web services. You will also learn more about the SOAP protocol and related standards.

CHAPTER 9



XML in Web Services

The idea of distributed application development is not new. Distributed technologies such as Distributed Component Object Model (DCOM), Remote Method Invocation (RMI), and Common Object Request Broker Architecture (CORBA) have existed for years. However, none of these technologies is an unambiguous industry standard. That is where standards based services step in. A service exposes some functionality as an API (Application Programming Interface) that the clients can consume. The data transfer between the client and the service usually happens in a format known to both the parties (such binary, SOAP, XML, and JSON).

The .NET Framework allows you to build services using three main ways—Web Services (also called ASMX web services or XML web services), Windows Communication Foundation (WCF), and Web API. These frameworks have been developed at different points in time based on the industry trends and demands prevalent at those respective times. Web services allow you to build SOAP based services over HTTP. WCF is a generic service development framework that can deal with variety of communication channels such as TCP and HTTP and formats such as binary, SOAP, XML, and JSON. Web API is a framework for building HTTP based RESTful services. This chapter discusses the first flavor—the web services. The other two flavors are discussed in the next chapter.

It should be noted that web services are now considered an older way of developing services. Although .NET Framework and Visual Studio still support them, modern applications prefer WCF and Web API over web services. However, this chapter still discusses web services because that will allow you to become familiar with XML-based protocols and standards such as SOAP and WSDL.

Keep in mind that this chapter is not aimed at teaching you web service development in detail. It primarily focuses on building basic data driven ASMX web services and the role played by XML. Specifically, you learn about the following topics:

- What web services are
- Creating and consuming web services using the .NET Framework
- What SOAP is and how web services use it
- What WSDL is and what's its purpose

What Are Web Services?

The concept of web services can be best understood with the help of components that you might have built using the .NET Framework. What is a component? A *component* is a reusable piece of software that provides certain functionality to your application. For example, a component developed for a banking application might be providing services such as loan calculation, interest calculation, and so forth. If you need the same business logic at any other place, such a component will be of great use. Components also isolate your business logic from the rest of the application. Such components do not provide any user interface to your application. They simply provide the required services to you.

Generally, components reside on the same machine as your application. What if they are to be located on a separate server altogether? What if the network involved is not a LAN but the Internet? What if you want to host the components on a Unix box and consume them from a Windows machine? That is where web services come into the picture.

You can think of web services as components that reside on a web server, while applications consume them over a network. More formally, web services can be defined as a set of programmable APIs that can be called over a network using XML, SOAP, and HTTP.

Web services are an industry standard, and no single company owns web services. The three standards—XML, SOAP, and HTTP—are the pillars of the web service infrastructure. The following are some points to be remembered about web services:

- Web service standards are platform-independent industry standards.
- Web services do not provide any user interface. They provide only functionality or services to your application.
- Web services use XML, SOAP, and HTTP as the communication protocols.
- Web services use the same request-response model as used by web applications.
- All communication between a web service and its client happens in a plain-text format.
- Web services can reside on any web server as long as the client has network connectivity with that server.
- A web service and its client can be developed using completely different platforms. For example, you may develop a web service using the .NET Framework and consume it in a Java application.
- Web services under .NET Framework are also called ASMX web services due to the file extension used by the web service files (*.asmx).

Creating and Consuming Web Services

Building web services requires three essential steps:

- Creating a web service
- Creating a proxy for the web service
- Creating a client application that consumes the web service

Modern software development platforms often introduce the concept of a proxy while performing remote communication. A *proxy* is an entity that stands in for some other entity and pretends to your client application that the proxy itself is the actual web service. In doing so, the proxy shields you from low-level network programming details (such as socket programming, underlying protocols, communication formats, and security). Your client application never talks with the web service directly. All the communication (request as well as response) is routed through the proxy.

If the proxy wants to pretend that the proxy itself is the web service, it must look like the web service. This requires the detailed description or metadata of a web service. The web service standards provide what is known as Web Services Description Language (WSDL). WSDL is an XML dialect that describes the web service, listing details such as the functions exposed by the web service, their parameters, data types, and return values. The proxy is generated using this WSDL document of a web service.

The file extension used by .NET Framework web services is .asmx. The web service .asmx files can have code-behind files just like ASP.NET Web Forms.

Creating a Web Service

To create a web service using Visual Studio, you need to create a new web application named EmployeeWebService and then add an ASMX web service to it. Figure 9-1 shows the New Project dialog of Visual Studio.

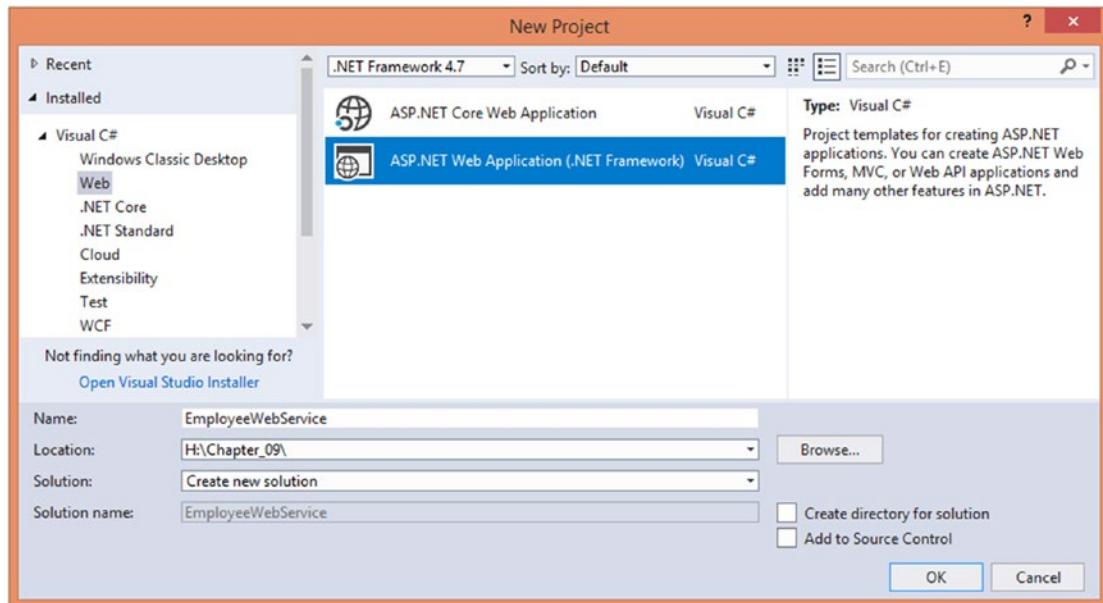


Figure 9-1. Creating a new web application project in Visual Studio

Once you select ASP.NET Web Application as the project type and click OK, select Empty as the project template. Also make sure to check the Web Forms checkbox. This dialog is shown in Figure 9-2.

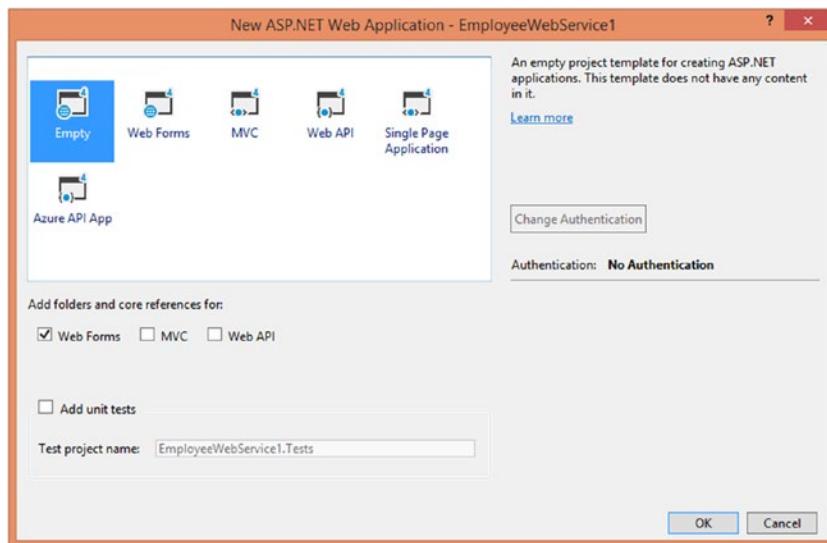


Figure 9-2. Creating a Web Forms project using the Empty project template

After you create the project, add a folder under the project root folder named Services. Then right-click on the Services folder and choose Add ➔ New Item. This will open the Add New Item dialog, as shown in Figure 9-3.

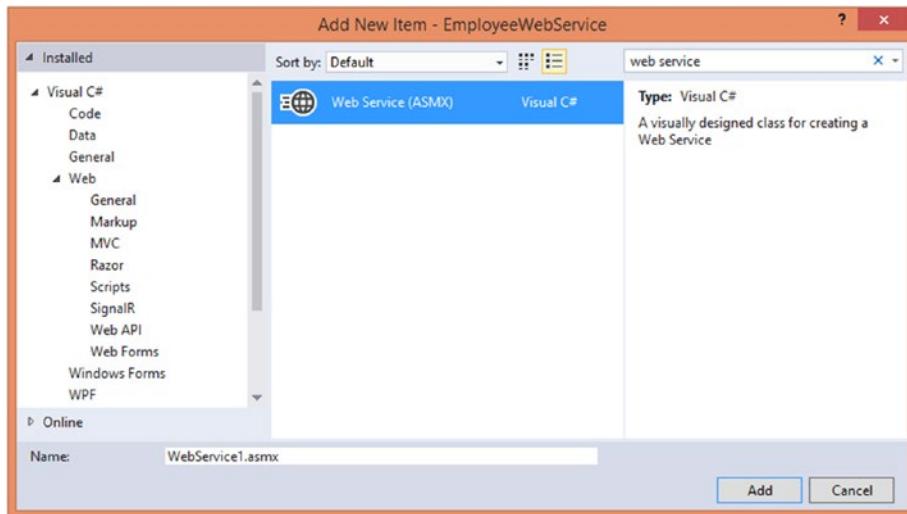


Figure 9-3. Adding a new Web Service (ASMX) to the project

Search for web service or locate a web service entry from the list. Specify web service name as EmployeeManager.asmx and click the Add button.

Now you should see the EmployeeManager.asmx as well as its code-behind file—EmployeeManager.cs. The .asmx file contains the markup shown in Listing 9-1.

Listing 9-1. @WebService Directive

```
<%@ WebService Language="C#" CodeBehind="EmployeeManager.asmx.cs" Class="EmployeeWebService.Services.EmployeeManager" %>
```

The @WebService directive specifies that this is a web service. Note that the CodeBehind attribute points the EmployeeManager.asmx.cs file. The Class attribute specifies the class from the CodeBehind file that contains web service functionality. If you open the EmployeeManager.asmx.cs file, you should see something similar to Listing 9-2.

Listing 9-2. The Web Service Class

```
[WebService(Namespace = "http://tempuri.org/")]
[WebServiceBinding(ConformsTo = WsiProfiles.BasicProfile1_1)]
public class EmployeeManager : System.Web.Services.WebService
{
    [WebMethod]
    public string HelloWorld()
    {
        return "Hello World";
    }
}
```

Here we have a class called `EmployeeManager` that inherits from `System.Web.Services.WebService` class. Actually, inheriting from the `WebService` class is not mandatory, but doing so will give you added facilities such as state maintenance. Inside this class we have a public method called `HelloWorld()`. The method by itself does not contain anything special—you must have written many such methods in your own applications. What makes it special, however, is the `WebMethod` attribute, which makes the method web callable—that is, the client application can call this method over a network. Your class can contain any number of public or private methods. However, only the methods that are public and decorated with the `WebMethod` attribute are web callable.

Notice that the Service class is decorated with the `[WebService]` and `[WebServiceBinding]` attributes. The `[WebService]` attribute is used to specify some additional information about the web service such as its description and namespace. The `Namespace` property indicates the default XML namespace to use for the XML web service. The XML namespaces allow you to uniquely identify elements and attributes from an XML document. Every web service needs to have a unique XML namespace to identify itself so that client applications can distinguish it from other web services. By default, this namespace is set to `http://tempuri.org/` but it is recommended that you change it to some other URI. For example, you can use the domain name of your company as the namespace. Note that although many times the XML namespaces are URLs, they need not point to actual resources on the Web. The `[WebServiceBinding]` attribute specifies a WSDL binding used by that service. You may think of a WSDL binding as an interface that defines a set of web service operations. The `ConformsTo` attribute specifies the Web Services Interoperability (WSI) specification. The WS-I organization provides guidelines for web services interoperability across multiple platforms.

Run the application and you should see something similar to Figure 9-4.

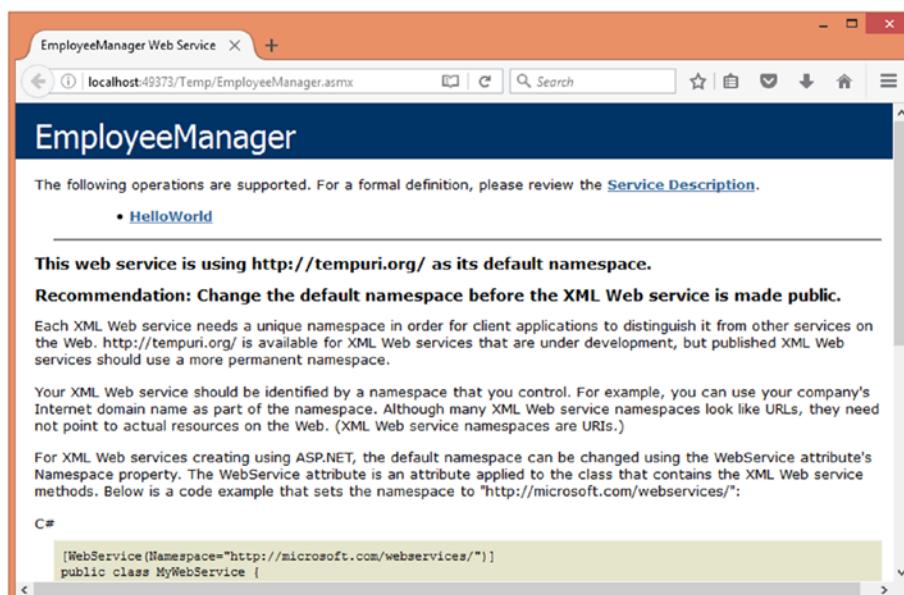


Figure 9-4. Web service help page

You might be wondering why our web service is showing this user interface when we know that web services do not have a user interface. Actually, this is not a user interface of the web service. This interface is called a *web service help page* and allows you to test your web services. Because web services by themselves do not have a user interface, how will you or your clients test them to see whether they function correctly? To help you in such cases, ASP.NET generates these help pages automatically. At the top of the help page, you will see a link titled Service Description. Just click on it and you will be presented with the WSDL of your web service (see Figure 9-5).

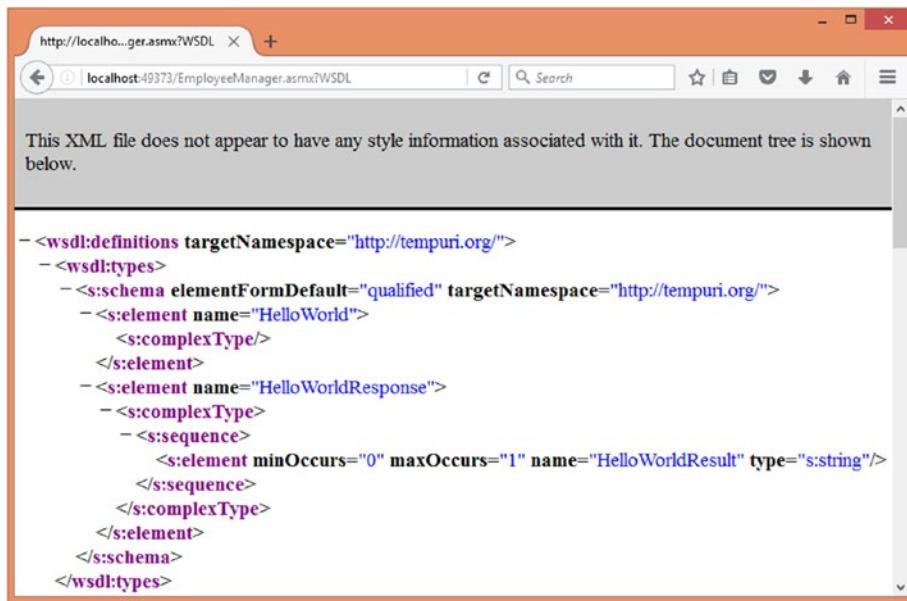


Figure 9-5. WSDL of a web service

Have a look in the address bar. Do you see the WSDL in the query string? This is how you can manually retrieve the WSDL of any ASP.NET web service. Simply attach *WSDL* at the end of the web service URL and you get the WSDL. Click the Back button to return to the previous page. You will notice the list of web methods (operations). Click the *HelloWorld* web method. You will be taken to another help page wherein you can execute this web method (see Figure 9-6).

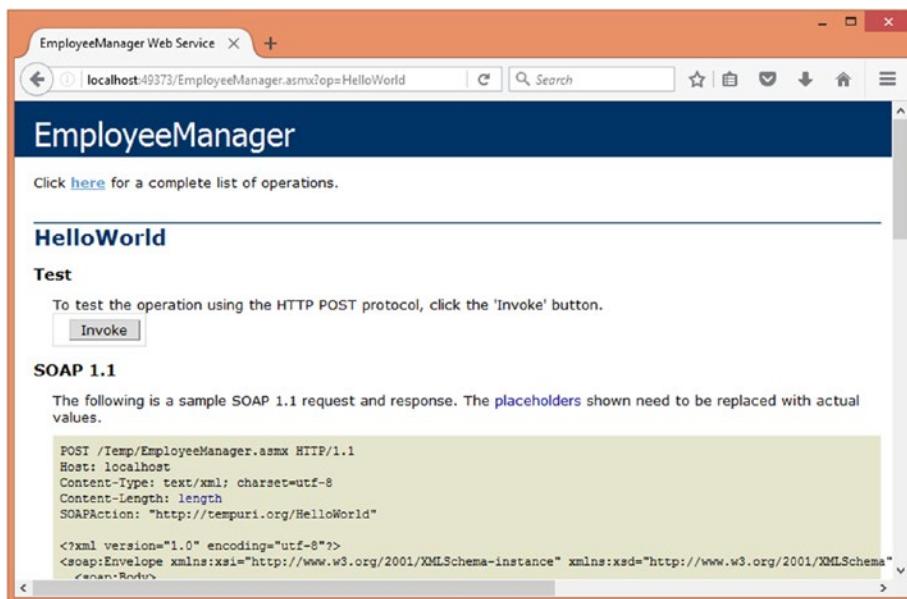


Figure 9-6. Invoking a web method

Before you click the Invoke button, have a look below it. You should see markup, as shown in Listings 9-3 and 9-4.

Listing 9-3. SOAP Request

```
POST /EmployeeWebService/EmployeeManager.asmx HTTP/1.1
Host: localhost
Content-Type: text/xml; charset=utf-8
Content-Length: length
SOAPAction: "http://tempuri.org/HelloWorld"

<?xml version="1.0" encoding="utf-8"?>
<soap:Envelope xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/">
  <soap:Body>
    <HelloWorld xmlns="http://tempuri.org/" />
  </soap:Body>
</soap:Envelope>
```

Listing 9-4. SOAP Response

```
HTTP/1.1 200 OK
Content-Type: text/xml; charset=utf-8
Content-Length: length

<?xml version="1.0" encoding="utf-8"?>
<soap:Envelope xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/">
  <soap:Body>
    <HelloWorldResponse xmlns="http://tempuri.org/">
      <HelloWorldResult>string</HelloWorldResult>
    </HelloWorldResponse>
  </soap:Body>
</soap:Envelope>
```

These two blocks represent the SOAP request being sent to the web service and the SOAP response being received from the web service. As you can see, the SOAP request and response consist of a tag called `<soap:Envelope>`. Inside there is a mandatory tag called `<soap:Body>`. The Body tag contains the XML data being passed or returned. There can be an optional tag, `<soap:Header>`, inside the `<soap:Envelope>` tag that can be used to pass arbitrary data to the web service.

Now click the Invoke button. The help page will execute the web method and open another window to show the web method response (see Figure 9-7).

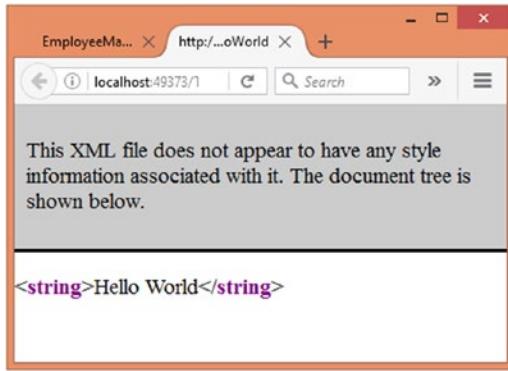


Figure 9-7. Hello World response

Now close the browser and return to Visual Studio. Modify the `HelloWorld()` method, as shown in Listing 9-5.

Listing 9-5. Web Method with a String Parameter

```
[WebMethod]
public string HelloWorld(string name)
{
    return "Hello " + name;
}
```

Here we have added one string parameter to the `HelloWorld()` method. The method now returns `Hello` concatenated with the name supplied. Run the web service again. This time you should see a help page, as shown in Figure 9-8, for invoking the web method.

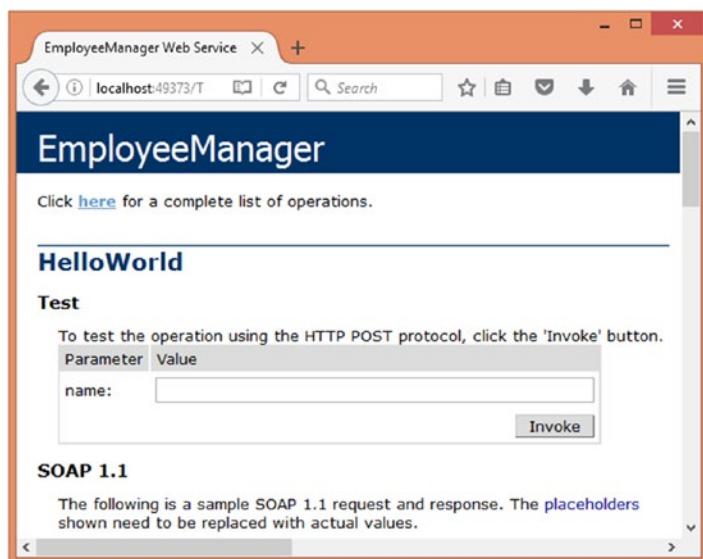


Figure 9-8. Invoking a web method with a string parameter

ASP.NET automatically generates a text box for you to enter the parameter. Of course, this works only for primitive data types such as strings and integers. ASP.NET will not be able to do so for array, object, or collection parameters.

Setting a Description for a Web Method

You can set a description for a web method by using the `Description` property of the `WebMethod` attribute. This description will be displayed on the help page. The code in Listing 9-6 illustrates its use.

Listing 9-6. Using the Description Property

```
[WebMethod(Description = "This is description for web method")]
public string HelloWorld()
{
    return "Hello World";
}
```

Adding Web Methods for CRUD Functionality

Now let's add a few web methods that are more meaningful and perform some database operations.

In this section you will add five web methods to the `EmployeeManager` web service. These methods will implement the CRUD (Create, Read, Update and Delete) functionality and perform the respective database operations on the `Employees` table of the Northwind database.

This example will use Entity Framework (EF) code-first approach to perform the database operations. Many modern applications use Entity Framework for database tasks. We use EF here just to save some time and to simplify our code. If you want, you can use ADO.NET code instead of Entity Framework.

Note Although this section doesn't use any advanced EF concepts, it is assumed that you have basic familiarity with Entity Framework code-first. If that's not the case, you may consider learning the basics of EF code-first before continuing with this section.

Make sure that the project you just created is opened in Solution Explorer. Notice that there is Models folder under the project root. We will use this folder to store Entity Framework models. Right-click on the Models folder and select Add ➤ New Item from the shortcut menu. From the Add New Item dialog, pick ADO.NET Entity Data Model entry (see Figure 9-9).

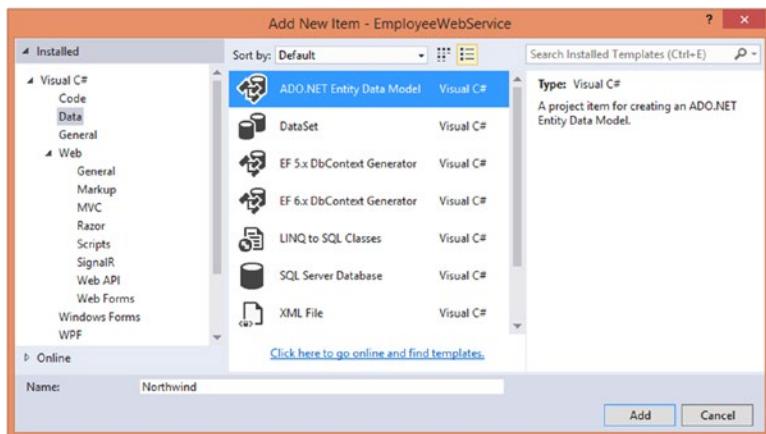


Figure 9-9. Adding an EF data model

Specify the model name to be **Northwind** and click the Add button. This will open a wizard, as shown in Figure 9-10.

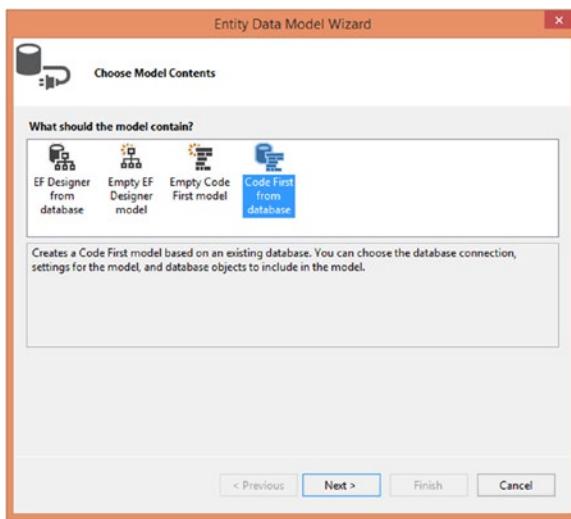


Figure 9-10. Generating a context using code-first approach

This dialog allows you to pick how the context is to be created. Select Code First from database option and click Next.

The next dialog (see Figure 9-11) allows you to specify the database connection string information. Go ahead and enter these details as per your database setup and security credentials. Click Next when you're ready.

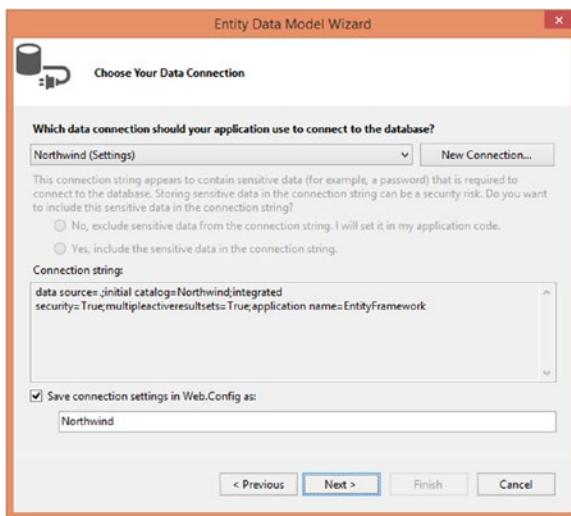


Figure 9-11. Specifying database connection string details

The next wizard step (see Figure 9-12) allows you to select one or more database tables you want to use. In our example, you need only one table—Employees. Select that table and finish the wizard.

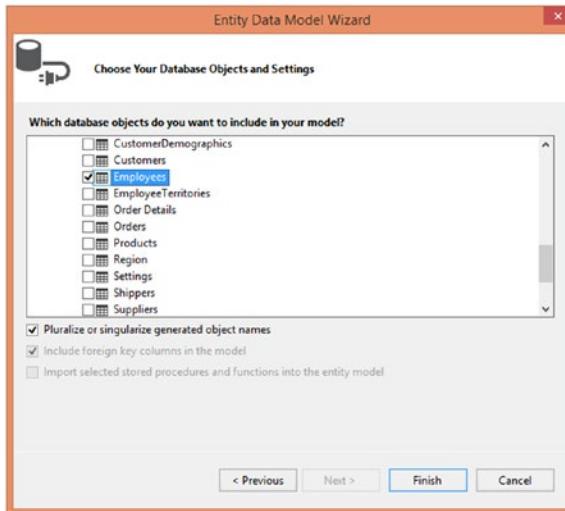


Figure 9-12. Selecting the Employees table

Successfully completing the wizard will add two files to the Models folder—Northwind.cs and Employee.cs. The former file contains a class that inherits from DbContext and the latter file contains the Employee entity class.

Since we are interested only in the five columns—EmployeeID, FirstName, LastName, HomePhone, and Notes—remove all the other properties from the Employee entity class. Listing 9-7 shows the final Employee class.

Listing 9-7. Final Employee Entity Class

```
public partial class Employee
{
    public int EmployeeID { get; set; }
    public string LastName { get; set; }
    public string FirstName { get; set; }
    public string HomePhone { get; set; }
    public string Notes { get; set; }
}
```

The Employee class contains five public properties that map to the respective columns of the Employees table. Also, modify the Northwind context class to match Listing 9-8.

Listing 9-8. Northwind Context Class

```
public partial class Northwind : DbContext
{
    public Northwind()
        : base("name=Northwind")
    {
    }

    public virtual DbSet<Employee> Employees { get; set; }
}
```

The Northwind context contains a single DbSet called Employees. This completes our EF model and we are ready to add the CRUD functionality to the EmployeeManager web service.

Now we will add five web methods to the EmployeeManager web service. These web methods are SelectAll(), SelectByID(), Insert(), Update(), and Delete(). These web methods do the respective operation. Let's discuss them one-by-one.

Listing 9-9 shows the SelectAll() web method.

Listing 9-9. SelectAll() Web Method

```
[WebMethod]
public List<Employee> SelectAll()
{
    using (Northwind db = new Northwind())
    {
        return db.Employees.OrderBy(e => e.EmployeeID).ToList();
    }
}
```

The SelectAll() web method returns a List of Employee objects. Inside, it creates a Northwind context object. It then selects all the Employee objects using the Employees DbSet, orders them on EmployeeID and then returns the list to the caller. Notice that SelectAll()—and all the other methods—is decorated with the [WebMethod] attribute.

Next, add the SelectByID() web method, as shown in Listing 9-10.

Listing 9-10. SelectByID() Web Method

```
[WebMethod]
public Employee SelectByID(int id)
{
    using (Northwind db = new Northwind())
    {
        return db.Employees.Find(id);
    }
}
```

The SelectByID() web method accepts an integer ID parameter representing an EmployeeID and returns an Employee object matching that value. Inside, it uses the Find() method on the Employees DbSet to grab the Employee object with the matching ID.

Now add Insert() web method, as shown in Listing 9-11.

Listing 9-11. Insert() Web Method

```
[WebMethod]
public string Insert(Employee obj)
{
    using (Northwind db = new Northwind())
    {
        db.Employees.Add(obj);
        db.SaveChanges();
        return "Employee added successfully!";
    }
}
```

The `Insert()` web method accepts an `Employee` object containing the details of an employee to be added to the database and returns a success message. Inside, it adds the `obj` to the `Employees` `DbSet` using the `Add()` method. The `SaveChanges()` method is then called to persist the changes to the database. Finally, a success message is returned to the caller.

Now it's time to add the `Update()` web method, as shown in Listing 9-12.

Listing 9-12. Update() Web Method

```
[WebMethod]
public string Update(Employee emp)
{
    using (Northwind db = new Northwind())
    {
        db.Entry(emp).State = EntityState.Modified;
        db.SaveChanges();
        return "Employee modified successfully!";
    }
}
```

The `Update()` web method accepts an `Employee` object that needs to be updated in the database. Inside, it changes the `State` property of the entity to `Modified`. This is done using the `Entry()` method of the context and `EntityState` enumeration. As before, `SaveChanges()` is called to save the changes to the physical database. Finally, a success message is returned to the caller.

Complete the `EmployeeManager` web service by adding the `Delete()` web method, as shown in Listing 9-13.

Listing 9-13. Delete() Web Method

```
[WebMethod]
public string Delete(int id)
{
    using (Northwind db = new Northwind())
    {
        Employee emp = db.Employees.Find(id);
        db.Employees.Remove(emp);
        db.SaveChanges();
        return "Employee deleted successfully!";
    }
}
```

The Delete() web method accepts an EmployeeID of an employee to be deleted. Inside, it finds the employee using the Find() method of Employees DbSet. It then removes that employee from the Employees DbSet using the Remove() method. SaveChanges() is called to save the changes to the physical database. Finally, a success message is sent to the caller.

This completes the EmployeeManager web service. Run it in the browser to display its help page. This time you will see the newly added five web methods, as shown in Figure 9-13.

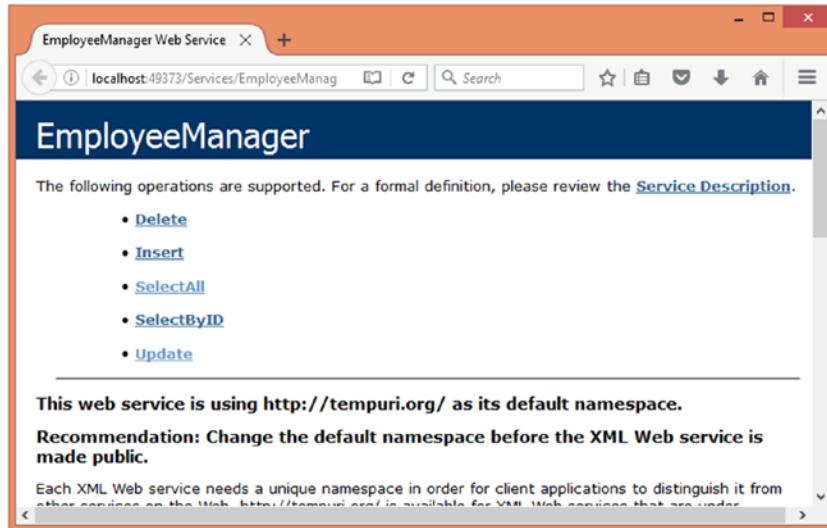


Figure 9-13. Web service help page listing all the CRUD web methods

Although you can't invoke all of them using the help page (because some of them need the Employee object as a parameter), you can try executing the SelectAll(), SelectByID(), and Delete() web methods. A sample outcome after running SelectByID() for EmployeeID of 1 is shown in Figure 9-14.

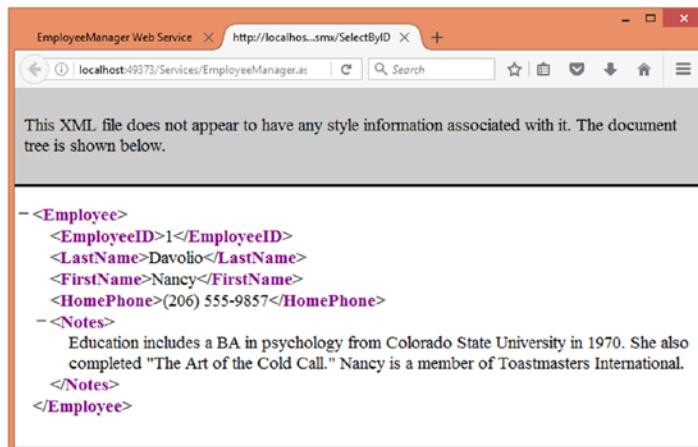


Figure 9-14. SelectByID() returning a single employee

As you can see, the data is being sent over the wire as an XML document.

Creating a Proxy for a Web Service

To create a proxy for the web service by using Visual Studio, you must first create the client application because the proxy always resides there. Though any type of application can act as a client to the web service, as an example we will create a Windows Forms application that consumes the EmployeeManager web service.

Add a new Windows Forms project to the current Visual Studio solution. Right-click on the References folder of this project in the Solution Explorer and choose the Add Service Reference shortcut menu option (see Figure 9-15).

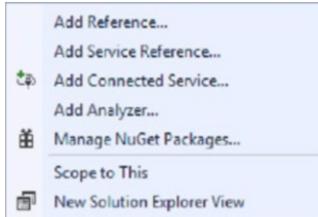


Figure 9-15. Add Service Reference menu option

Doing so will open the Add Service Reference dialog, as shown in Figure 9-16.

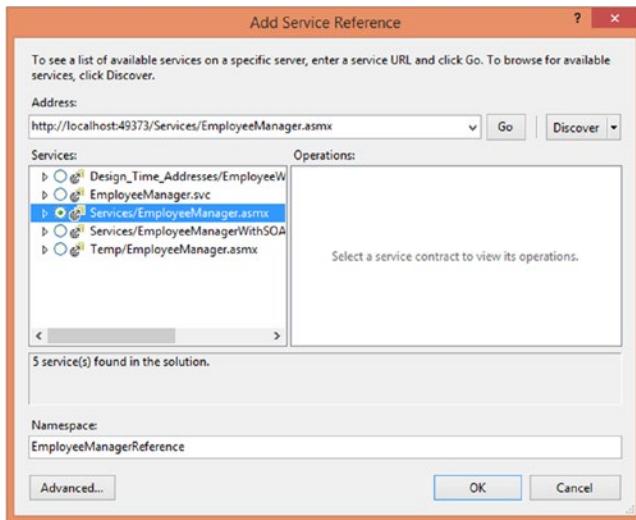


Figure 9-16. Add Service Reference dialog

Clicking on the Discover button will list all the services (including the EmployeeManager.asmx) under the Services section. Selecting EmployeeManager.asmx will reveal its URL under the Address area. If your service is external to the solution, you would have manually typed its URL here.

The Namespace text box allows you to specify a namespace name for the proxy class being generated. Enter **EmployeeManagerReference** in this text box and click the OK button. This will generate a "WCF style" proxy for your web service and place it under the Service References folder (see Figure 9-17).

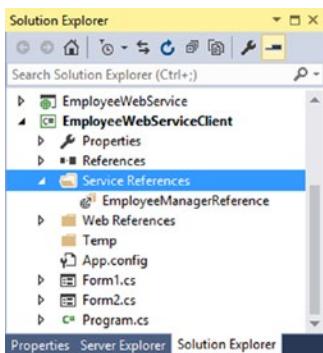


Figure 9-17. *EmployeeManagerReference* is placed inside the Service References folder

There is an alternate way to generate the proxy through the same Add Service References option—using Web Reference. Let's see how that works. Open the same Add Service Reference dialog. There is Advanced button located at the bottom of the dialog. Clicking on it opens Service Reference Settings dialog, as shown in Figure 9-18.

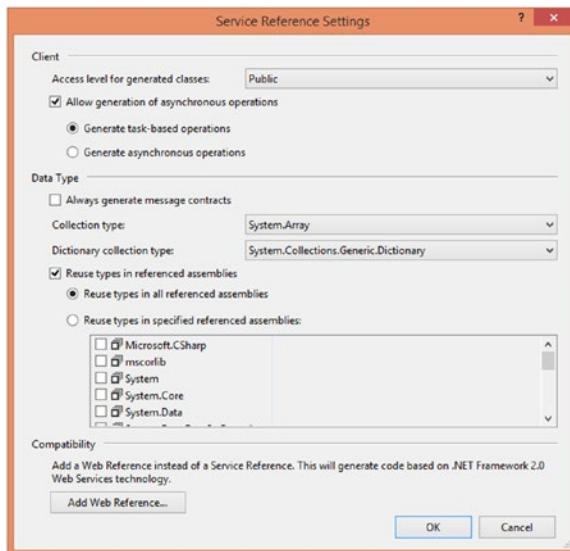


Figure 9-18. *Service Reference Settings* dialog

There is Add Web Reference button at the bottom of this dialog (under the Compatibility section). Clicking it opens another dialog—Add Web Reference (see Figure 9-19).

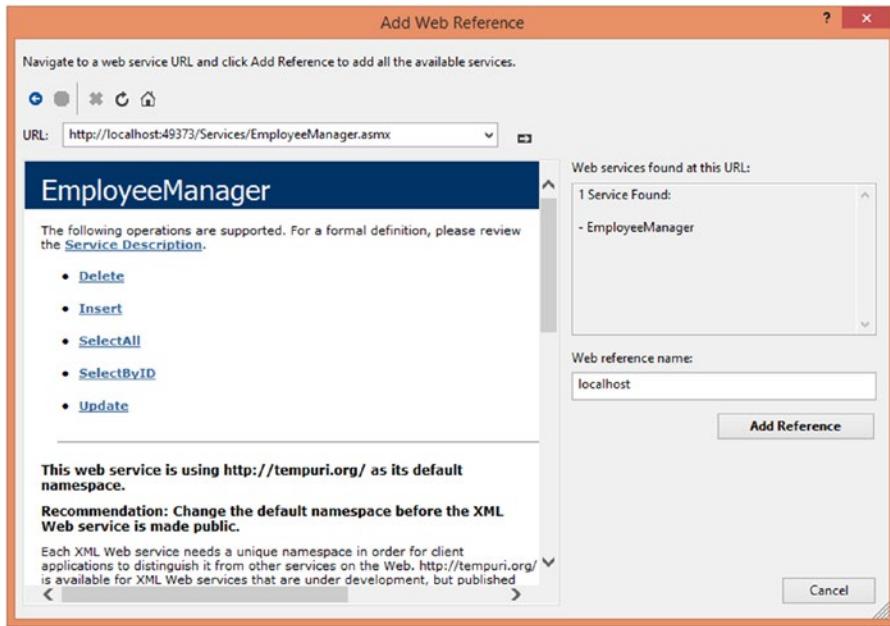


Figure 9-19. Using the Add Web Reference dialog to generate the proxy

You can navigate to the EmployeeManager web service, give some web reference name (namespace name), and click on the Add Reference button. Web references are stored under Web References folder. It should be noted that web reference is an older way of generating the proxy. You should use it only when backward compatibility is necessary.

Irrespective of the way you generated the proxy (either a service reference or a web reference), you can always update a proxy by right-clicking on it in the Solution Explorer and selecting the Update Service Reference or Update Web Reference shortcut menu option, respectively. Also note that generating a proxy also adds certain markup in the application's configuration file. You shouldn't tamper this configuration unless you are sure about the changes you are making.

Creating a Form That Calls the Web Methods

To demonstrate how to call web methods, you will need to create a form that will allow you to add, modify, and delete employees from the Employees table. The form should look like Figure 9-20.

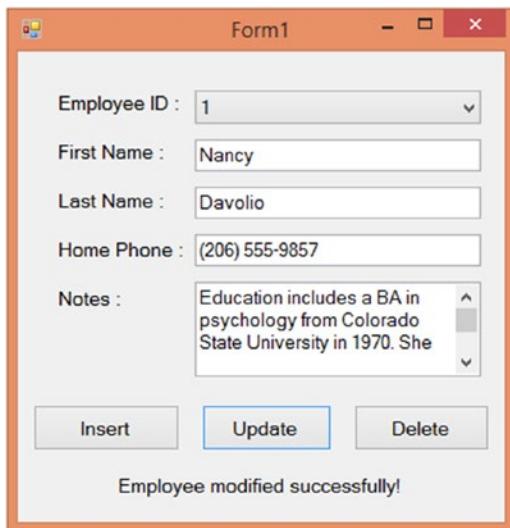


Figure 9-20. Application that calls the web methods

The form displays a list of existing EmployeeIDs in a dropdown list. If you select an EmployeeID from the dropdown list, its details—such as first name, lastname, home phone, and notes—are displayed in the respective text boxes. You can then either modify the details, and click the Update button, or you can delete that employee by clicking the Delete button. To add a new employee, you need to fill in the details in the respective fields (EmployeeID is an identity column and hence will be autogenerated by the database). Clicking on the Insert button saves the new employee details into the database. A success message as returned by the web methods is displayed in a label below the buttons.

The dropdown list is filled with a list of existing EmployeeIDs in the Load event of the form. Listing 9-14 shows how this is done.

Listing 9-14. Filling EmployeeIDs in the Dropdown List

```
private void Form1_Load(object sender, EventArgs e)
{
    EmployeeManagerSoapClient proxy = new EmployeeManagerSoapClient();
    Employee[] data = proxy.SelectAll();
    foreach(Employee emp in data)
    {
        comboBox1.Items.Add(emp.EmployeeID);
    }
}
```

The code creates an instance of the proxy class—EmployeeManagerSoapClient. This class (and also the Employee class in the client application) comes from the EmployeeWebServiceClient. EmployeeManagerReference namespace and hence you need to import the namespace before using this class. Note that we discussed two ways of generating the proxy. Here the code is using the “WCF style” proxy to call the web service. The name of the generated proxy class is formed by appending SoapClient to the end of the original web service class (EmployeeManager).

Then the code calls the `SelectAll()` method on the proxy. The `SelectAll()` method of the web service returns a List of Employee objects. That list is received as an array in the client code. You can fine-tune this behavior while generating the proxy (the Advanced Settings dialog). Here we will stick to the default settings since they are sufficient to demonstrate the functioning of the web service. A foreach loop iterates through the array and fills the dropdown list with all the EmployeeID values.

Upon selecting an EmployeeID, its details are populated in the other text boxes. This is done in the `SelectedIndexChanged` event of the dropdown list (see Listing 9-15) by invoking the `SelectByID()` web method.

Listing 9-15. Calling the `SelectByID()` Web Method

```
private void comboBox1_SelectedIndexChanged(object sender, EventArgs e)
{
    EmployeeManagerSoapClient proxy = new EmployeeManagerSoapClient();
    Employee data = proxy.SelectByID((int)comboBox1.SelectedItem);
    textBox1.Text = data.FirstName;
    textBox2.Text = data.LastName;
    textBox3.Text = data.HomePhone;
    textBox4.Text = data.Notes;
    label6.Text = "";
}
```

The code creates a proxy object as before. It then calls the `SelectByID()` method on the proxy by passing the selected EmployeeID. The `SelectByID()` method returns an `Employee` object. Details of the employee—such as `FirstName`, `LastName`, `HomePhone`, and `Notes`—are populated in the respective text boxes.

To add a new employee, you need to fill all the text boxes with the corresponding values and click the Insert button. The `Click` event handler of the Insert button then calls the `Insert()` web method. This is shown in Listing 9-16.

Listing 9-16. Calling the `Insert()` Web Method

```
private void button2_Click(object sender, EventArgs e)
{
    EmployeeManagerSoapClient proxy = new EmployeeManagerSoapClient();
    Employee data = new Employee();
    data.FirstName = textBox1.Text;
    data.LastName = textBox2.Text;
    data.HomePhone = textBox3.Text;
    data.Notes = textBox4.Text;
    label6.Text = proxy.Insert(data);
}
```

The code creates a proxy object and a new `Employee` object. This `Employee` object represents a new employee to be added into the database. Properties such as `FirstName`, `LastName`, `HomePhone`, and `Notes` are set to the values entered into the respective text boxes. Finally, the `Insert()` method is called on the proxy to add the employee. The `Insert()` method returns a success message (assuming that there was no exception) that is then displayed in a Label.

To modify an employee's details, you need to select the EmployeeID from the dropdown list and then change the values from the text boxes. Once you've added the changes, clicking on the Update button attempts to save the modified details by calling the `Update()` web method. This is shown in Listing 9-17.

Listing 9-17. Calling the Update() Web Method

```
private void button1_Click(object sender, EventArgs e)
{
    EmployeeManagerSoapClient proxy = new EmployeeManagerSoapClient();
    Employee data = new Employee();
    data.EmployeeID = (int)comboBox1.SelectedItem;
    data.FirstName = textBox1.Text;
    data.LastName = textBox2.Text;
    data.HomePhone = textBox3.Text;
    data.Notes = textBox4.Text;
    label6.Text=proxy.Update(data);
}
```

The code is almost identical to the `insert` operation discussed earlier. The only difference is that it picks an `EmployeeID` from the dropdown list instead of the text box (since an existing employee is being modified). And the `Update()` method is called on the proxy after assigning all the properties of the `Employee` object.

Removing an employee is straightforward. All you need to do is select an `EmployeeID` from the dropdown list and click on the Delete button. The code that removes an employee is shown in Listing 9-18.

Listing 9-18. Calling the Delete() Web Method

```
private void button3_Click(object sender, EventArgs e)
{
    EmployeeManagerSoapClient proxy = new EmployeeManagerSoapClient();
    int id = (int)comboBox1.SelectedItem;
    label6.Text = proxy.Delete(id);
}
```

The code simply calls the `Delete()` method on the proxy by passing an `EmployeeID` to be deleted. This completes the client application. Run the application and test whether CRUD operations are working as expected. To better understand the flow of execution, you can set breakpoints in various event handlers as well as in the web methods.

Understanding SOAP

In the previous section, you learned that SOAP is a lightweight XML-based protocol that forms one of the building blocks of the web service infrastructure. You also learned how web service requests and responses are encoded in SOAP format. Now it's time to peek inside SOAP in a bit of detail. Have a look at Listing 9-19.

Listing 9-19. SOAP Request

```
POST /WebServiceDemos/Service.asmx HTTP/1.1
Host: localhost
Content-Type: text/xml; charset=utf-8
Content-Length: length
SOAPAction: "http://tempuri.org/HelloWorld"
<?xml version="1.0" encoding="utf-8"?>
<soap:Envelope xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema"
```

```

xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/">
<soap:Body>
  <HelloWorld xmlns="http://tempuri.org/" />
</soap:Body>
</soap:Envelope>
```

As you might have guessed, Listing 9-20 represents a SOAP request. If you observe this markup carefully, you will find that the request consists of an envelope (<soap:Envelope>) and body (<soap:Body>). In fact, a SOAP request or response can contain four possible parts. Each of these parts is described in Table 9-1.

Table 9-1. Parts of a SOAP Message

Part	Description
Envelope	Wraps the SOAP request or response. It is the root element of the SOAP message and is represented by the <soap:Envelope> markup tag. All SOAP messages must have an envelope.
Header	Optional parts of a SOAP message. They are used to pass arbitrary data to and from the web service and its client. For example, you can use them to pass authentication information to the web service. A SOAP header is represented by the <soap:Header> markup tag.
Body	A mandatory part of a SOAP message. It includes the actual request or response data in XML format. The SOAP body is represented by the <soap:Body> markup tag.
Fault	An optional part of a SOAP message. It comes into the picture whenever there is a runtime exception in the web service. The exception details are enclosed in the <soap:Fault> tag and sent back to the client application.

Using SOAP Headers

In this section, you will modify the EmployeeManager web service and the client application to use SOAP headers. Let's assume that in order to successfully call the EmployeeManager web service, the client is supposed to send a secret Key to the web service. With every call to a web method, the web service needs to check for the existence of a valid Key.

Now the question is—how would you pass the secret key from the client to the service? One option would be to include it in the signature of all the web methods. But this will complicate the web methods and make future changes difficult. A better alternative is to pass the secret key via a custom SOAP header. The web service will authenticate a call on the basis of this SOAP header and return the requested data only if the key is validated.

To begin the modification, add a class called EmployeeManagerHeader in the Services folder (you can place it in any other folder if you so wish). This class wraps the secret key and consists of just a single property: ClientKey. Listing 9-20 shows the completed User class.

Listing 9-20. Creating a Class That Inherits from the SoapHeader Class

```

public class EmployeeManagerHeader:SoapHeader
{
    public string ClientKey { get; set; }
}
```

Notice that the EmployeeManagerHeader class inherits from the SoapHeader base class, which resides in the System.Web.Services.Protocols namespace and represents a basic SOAP header. All the custom SOAP header classes must inherit directly or indirectly from the SoapHeader class. Make sure that you have imported the System.Web.Services.Protocols namespace before creating the User class.

The User class simply contains a string property—ClientKey. After you create the EmployeeManagerHeader class, modify the EmployeeManager web service as shown in Listing 9-21.

Listing 9-21. Using a SOAP Header

```
public class EmployeeManager : System.Web.Services.WebService
{
    public EmployeeManagerHeader Header;

    [WebMethod]
    [SoapHeader("Header", Direction = SoapHeaderDirection.In)]
    public List<Employee> SelectAll()
    {
        if (Header==null)
        {
            throw new SoapHeaderException("SOAP header was not found!", SoapException.ClientFaultCode);
        }

        if(Header.ClientKey != "KEY001")
        {
            throw new SoapException("Invalid client key!", SoapException.ClientFaultCode);
        }

        using (Northwind db = new Northwind())
        {
            return db.Employees.OrderBy(e => e.EmployeeID).ToList();
        }
    }
    ...
    ....,
}
```

Examine the web service class carefully. At the top it declares a variable of type EmployeeManagerHeader. The SelectAll() web method is now decorated with an additional attribute called [SoapHeader]. This is how you specify information about a SOAP header.

The [SoapHeader] attribute specifies one parameter and one property. The first parameter specifies the name of the SOAP header member that we want to use. In our example, the name of the EmployeeManagerHeader variable is Header and hence that is what we pass to the web method. This member must be available publicly in the web service class. The Direction property indicates the direction of the SoapHeader and is of enumeration type SoapHeaderDirection. The possible values of the SoapHeaderDirection enumeration are as follows:

- In: The direction of In indicates that the SOAP header is passed from the client to the web service.
- Out: The direction of Out indicates that the SOAP header is passed from the web service to the client.

- **InOut:** The direction of InOut indicates that the SOAP header is passed to and from the web service and its client.
- **Fault:** The direction of Fault indicates that a SOAP header is to be sent to the client when the web method throws an exception.

Inside the `SelectAll()` web method, we check whether the SOAP header is null. If so, this indicates that the client key was not sent and hence the code raises a `SoapHeaderException`. The `SoapHeaderException` class is used to represent an error in the SOAP header. The first parameter of the `SoapHeaderException` constructor is the error message, and the second parameter is the SOAP fault code for the client call.

The code then checks the `ClientKey` property of the SOAP header. If the client key is incorrect, a `SoapException` is raised. The `SoapException` class is used to represent an error with the SOAP request processing. The constructor of `SoapException` takes the same two parameters as the `SoapHeaderException` class.

Note For the sake of simplicity the code uses a hard-coded string value for a client key. In a more realistic case you would check the key against some datastore. And the key might be encrypted for security reasons. Also, here we added the `[SoapHeader]` attributed to the `SelectAll()` web method. Repeat the same process for all the other web methods of the `EmployeeManager` web service.

To successfully consume the `EmployeeManager` web service you just modified, you need to modify the client application also. Listing 9-22 shows how the SOAP header required by the `SelectAll()` web method can be passed from the client application.

Listing 9-22. Passing a SOAP Header from the Client Application

```
private void Form2_Load(object sender, EventArgs e)
{
    EmployeeManagerSoapClient proxy = new EmployeeManagerSoapClient();

    EmployeeManagerHeader header = new EmployeeManagerHeader();
    header.ClientKey = "KEY001";

    try
    {
        Employee[] data = proxy.SelectAll(header);
        foreach (Employee emp in data)
        {
            comboBox1.Items.Add(emp.EmployeeID);
        }
    }
    catch(Exception ex)
    {
        MessageBox.Show(ex.Message);
    }
}
```

Before you write this code, make sure to update the proxy by right-clicking on it and selecting the Update Service Reference option. This is required because we have now changed the web service to use SOAP headers. And the proxy should know those details.

Notice the code marked in bold letters. The first line in bold letters creates an object of `EmployeeManagerHeader` and sets its `ClientKey` property. This class gets created on the client side during the proxy generation and placed in the same namespace as that of the proxy.

The second line in bold letters calls the `SelectAll()` method on the proxy. This time the SOAP header object—`header`—is passed as the method parameter. This way the `SelectAll()` web method will receive it from the client. Although here we will discuss only the `SelectAll()` method, you should modify all the other event handlers in the client application to use the SOAP header.

To test the client application, run it and check whether CRUD operations can be performed as before. Now, stop the application and explicitly set the `EmployeeManagerHeader` object to null. Then run the application again. You should get a message box, as shown in Figure 9-21, that informs you about the `SoapHeaderException`.

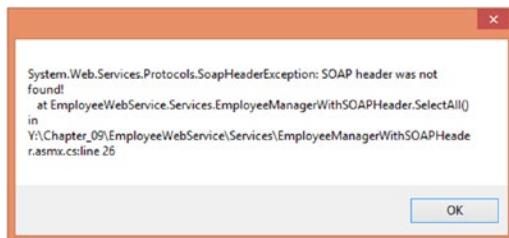


Figure 9-21. Catching a `SoapHeaderException`

Stop the application and revert the code that sets the header to null. Set the `ClientKey` property to some invalid key. Run the application again. This time the message box (see Figure 9-22) should inform you about the `SoapException` being thrown.

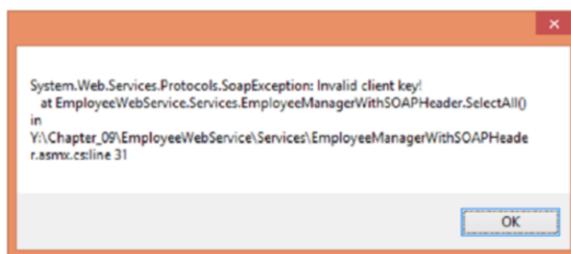


Figure 9-22. Catching `SoapException`

Note In the example that we just discussed, it was assumed that you are using a service reference. If you are using a web reference instead, the SOAP header is passed a bit differently. We won't discuss those differences here, but you can easily figure that out with the help of Visual Studio IntelliSense.

Customizing the XML Serialization

In the previous chapter it was mentioned that web services use `XmlSerializer` to serialize the XML data involved in the web service communication. This also means that you can use the attributes such as `[XmlRoot]` and `[XmlElement]` to customize the serialized outcome. Although we won't go into too much detail about this customization process, a simple illustration will give you some idea.

Consider the `Employee` class shown in Listing 9-23.

Listing 9-23. Customizing XML Serialization in Web Services

```
[XmlRoot(ElementName = "EmployeeRoot")]
public partial class Employee
{
    [XmlElement(ElementName = "EmpCode")]
    public int EmployeeID { get; set; }

    [XmlElement(ElementName = "LName")]
    public string LastName { get; set; }

    [XmlElement(ElementName = "FName")]
    public string FirstName { get; set; }

    [XmlAttribute]
    public string HomePhone { get; set; }

    [XmlElement(ElementName = "Remarks")]
    public string Notes { get; set; }
}
```

It is the same `Employee` class but this time attributes such as `[XmlRoot]` and `[XmlElement]` haven been added to customize the XML element names. The `HomePhone` property is decorated with `[XmlAttribute]` so as to ignore it from the serialization process.

If you invoke the `SelectByID()` web method using the help page, you should see something similar to Figure 9-23.

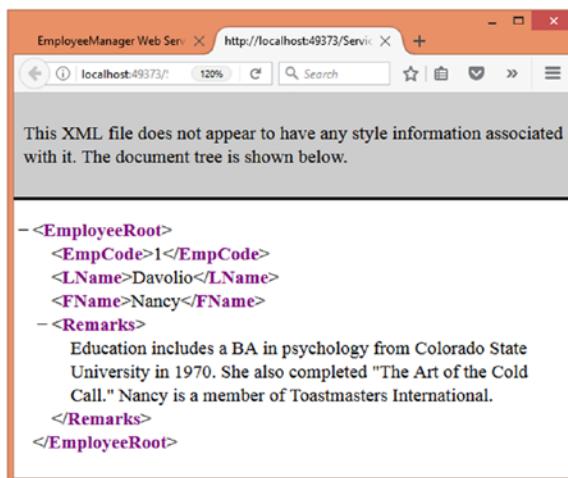


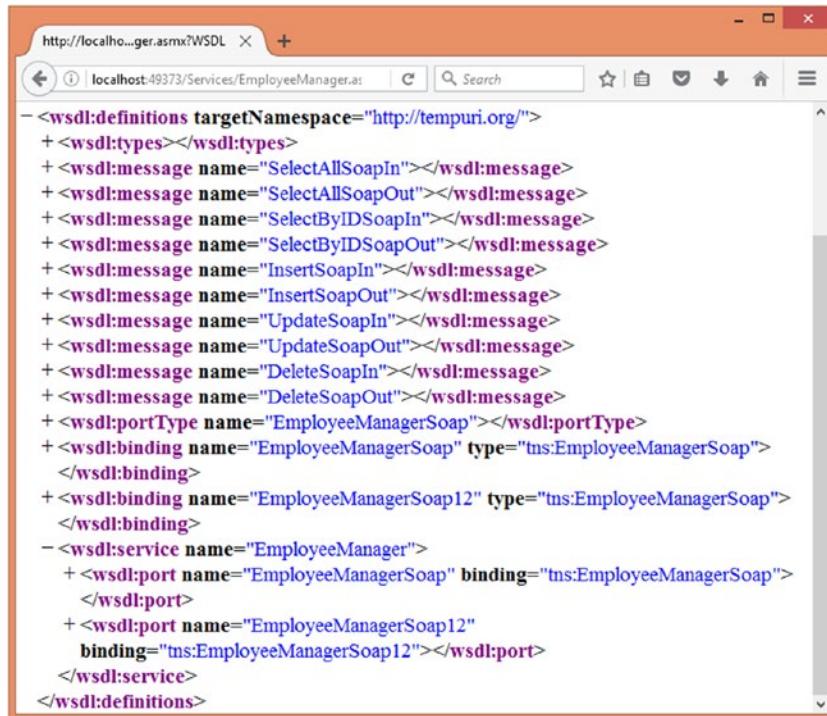
Figure 9-23. Customizing element names for serialization

As you can see, the serialized Employee object now uses element names such as <EmployeeRoot>, <FName>, <LName>, and <Remarks>. There is no HomePhone entry because we ignored it using [XmlAttribute].

Understanding the WSDL Document

While developing your first web service in this chapter, you learned that WSDL is an XML vocabulary that describes the web service in terms of web methods exposed, their parameters, data types, and return values. Though you will rarely modify or construct WSDL yourself (at least when you are using Visual Studio), it is helpful to understand the internal structure of the WSDL document. This way, your understanding of the web service metadata will broaden. You will also find the knowledge of WSDL useful while learning Windows Communication Foundation services, which are covered in Chapter 12.

Let's see the WSDL of a simple Hello World web service that we created initially in this chapter. We will be using this web service only as a sample. The discussion that follows is applicable to any other WSDL document. The WSDL of the preceding EmployeeManager web service, as shown in a browser, is shown in Figure 9-24.



The screenshot shows a Microsoft Internet Explorer window displaying the WSDL document for the EmployeeManager web service. The URL in the address bar is `http://localhost:49373/Services/EmployeeManager.asmx?WSDL`. The page content is the XML definition of the web service, which includes definitions for message types, port types, and service endpoints. The XML code is color-coded for readability, with tags in blue and attribute values in purple.

```

<wsdl:definitions targetNamespace="http://tempuri.org/">
  + <wsdl:types></wsdl:types>
  + <wsdl:message name="SelectAllSoapIn"></wsdl:message>
  + <wsdl:message name="SelectAllSoapOut"></wsdl:message>
  + <wsdl:message name="SelectByIDSoapIn"></wsdl:message>
  + <wsdl:message name="SelectByIDSoapOut"></wsdl:message>
  + <wsdl:message name="InsertSoapIn"></wsdl:message>
  + <wsdl:message name="InsertSoapOut"></wsdl:message>
  + <wsdl:message name="UpdateSoapIn"></wsdl:message>
  + <wsdl:message name="UpdateSoapOut"></wsdl:message>
  + <wsdl:message name="DeleteSoapIn"></wsdl:message>
  + <wsdl:message name="DeleteSoapOut"></wsdl:message>
  + <wsdl:portType name="EmployeeManagerSoap"></wsdl:portType>
  + <wsdl:binding name="EmployeeManagerSoap" type="tns:EmployeeManagerSoap">
    </wsdl:binding>
  + <wsdl:binding name="EmployeeManagerSoap12" type="tns:EmployeeManagerSoap">
    </wsdl:binding>
  - <wsdl:service name="EmployeeManager">
    + <wsdl:port name="EmployeeManagerSoap" binding="tns:EmployeeManagerSoap">
      </wsdl:port>
    + <wsdl:port name="EmployeeManagerSoap12"
      binding="tns:EmployeeManagerSoap12"></wsdl:port>
    </wsdl:service>
</wsdl:definitions>

```

Figure 9-24. WSDL of the EmployeeManager web service

If you observe this WSDL markup, you can identify six main parts of the document. These six parts are the core elements of any WSDL document and are listed in Table 9-2.

Table 9-2. Parts of WSDL

Part	Description
types	The <wsdl:types> element encloses all the type definitions from the web service.
message	The XML data that is being carried between the web service and its client. The <wsdl:message> element represents this message.
portType	The <wsdl:portType> section defines a group of operations (web methods) exposed by the web service. You may think of it as an interface that contains a series of <wsdl:operation> elements.
binding	The protocol and format used by the portType. It is represented by the <wsdl:binding> markup tag.
port	An endpoint of a web service communication. It is represented by the <wsdl:port> markup tag.
service	The collection of one or more ports. It is represented by the <wsdl:service> markup tag.

Let's look at each of these parts in more detail.

The Messages

You learned previously that web service communication works on the basis of a request and response model. A web service request as well as response consists of SOAP data. This SOAP data is called a *SOAP message*. Each web method has a message that represents a request for the web method and a message that represents the response from that web method. Thus our `SelectAll()` web method will have two messages:

- The name of the request message is of the form `XXXXSoapIn`, where `XXXX` is the name of the web method.
- Similarly, the name of the response message is of the form `XXXXSoapOut`, where `XXXX` is the name of the web method.

The WSDL message elements provide a consolidated list of all the messages exposed by the web service. The message names provided by this list are used everywhere else in the WSDL document.

The Type Definitions

Each message in a web service has a specific structure, or schema. This schema is specified by the `types` element of the WSDL document. If you observe the types section in the WSDL mentioned earlier, you will find that it specifies a schema for all the messages. You will also notice that the data type of the parameters and return values are specified here. This schema closely matches the XSD Schema you learned about in the earlier chapters.

The Port Types

A web service consists of one or more operations. In simple terms, an *operation* is analogous to a function or method. Each operation has an input message (request) and an output message (response). All the operations of a web service are listed under the `portType` section. The port name is of the form `XXXXSoap`, where `XXXX` is the name of the web service class. The `EmployeeManager` web service has five operations. Each operation consists of two messages—input message and output message. Recollect that messages are defined in the message section.

The Binding

A *binding* specifies the message format and protocol for each port type. For example, in our web service there is a binding defined for the `EmployeeManagerSoap` port type. The linking between a binding and port type is the `type` attribute of the `<wsdl:binding>` element. The binding name is of the form `XXXXSoap`, where `XXXX` is the name of the web service class.

The Service

A *service* is a set of ports and bindings. A web service port is a logical endpoint for a web service. A service has the same name as the web service class. In our example, the `service` element defines a port called `EmployeeManagerSoap` and links it with the `EmployeeManagerSoap` binding.

A Summary of WSDL

To summarize what we have discussed:

- A web service consists of one or more operations.
- Each operation typically has a request message and a response message.
- Each message is listed in the `message` section of the WSDL.
- The schema of all the messages is defined by the `types` section of the WSDL.
- All the operations exposed by a web service are listed under the `portType` section of the WSDL.
- For each port type, a transport format and protocol needs to be specified. This is referred to as *binding*.
- The binding for a port type is specified by the `binding` section of the WSDL.
- The `service` section of the WSDL defines an endpoint for the web service called a *port*.
- A port has a specific binding associated with it.

Summary

In this chapter, you learned about one of the powerful features of the .NET Framework: web services. Web services are a programmable set of APIs that can be called over a network by using industry standards such as XML, SOAP, and HTTP. Web services can prove to be very beneficial in areas such as application integration, cross-platform communication, and distributed communication over the Internet.

You learned to create web services, a proxy for the web service, and a client that consumes the web service. Finally, you peeked into the internal structure of SOAP and WSDL.

CHAPTER 10



XML in WCF and Web API

Chapter 9 introduced you to web services and you learned to develop service based applications. Web services are based on certain standards and protocols such as SOAP, XML and WSDL. They are great when it comes to developing standards based services that are accessed on the internet. However, at times your needs are different. For example, you may want to develop services for an intranet application and want to use binary format over TCP for performance reasons. Or you want to use some highly secure communication mechanism that uses some custom encryption strategies. Web services may not serve your purpose in such cases.

Recognizing the need to bridge the gap between various component technologies, Microsoft developed what is known as the *Windows Communication Foundation (WCF)*. WCF is a generic framework that provides a unified model for developing service-oriented software components. Under WCF you can employ the same piece of software regardless of whether you are using it over the Internet or an intranet. You can design and develop your software initially for TCP networks and later use it over HTTP. This can be achieved with no changes to the source code. What is more interesting for us is the fact that by default WCF uses XML (SOAP) as the data transfer format. That means data that is sent between the client and the server is in XML (SOAP) format. You can also customize how your objects are serialized on the wire.

WCF is a general purpose framework for developing services. It requires good amount of configuration. And many developers find this configuration tedious. Especially for web application where the underlying communication channel is HTTP and the data transfer is in some text-based format (XML, SOAP, JSON and so on) the extensive feature set and configuration of WCF is unnecessary. That's how Web API came into existence. Web API is a framework for building RESTful services. Web API framework is developed specifically keeping web applications and HTTP in mind and offers a simple programming model to the developers.

This chapter introduces you to the following topics:

- Common terms used in relation to WCF
- Creating and consuming a WCF service
- The role of XML in WCF services
- Creating and consuming a service using Web API
- Configuring the Web API to use XML format

Note This chapter is not intended to teach you the basics of WCF and Web API. It focuses more on how XML is related to these service development frameworks. If you are unfamiliar with WCF and Web API, consider learning their basics from the Microsoft's official documentation.

Operations Based Services vs. Resource Based Services

Broadly speaking, a service can be categorized either as an operation based service or a resource based service. What does that mean? Consider the `EmployeeManager` web service you developed in Chapter 9. You essentially added methods into the web service as per your requirement. In that example you added five methods to implement CRUD operations. But you could have added as many as you want depending on your requirement. Later you invoked those methods by calling them on the proxy. Thus you explicitly invoked operations of a service. This was an example of operations based service.

Resource based services are resource oriented. A resource could be anything, say, business objects, a database or a file. A resource based service allows you to perform actions on a resource such as adding a resource, updating a resource, removing a resource and fetching a resource. Thus a resource based service confines itself to a resource. This is different than operations based service where the service is free to do anything of your choice. RESTful services are resource based services (you will learn more about REST in later sections).

Each approach of developing a service has its own pros and cons. We won't go into those details in this book. Suffice it to say that WCF allows you to develop both kinds of services, whereas Web API allows you to build RESTful services. In the later sections of this chapter, you will develop both kinds of services. You will also observe where XML fits into this whole picture.

Understanding WCF Vocabulary

In Chapter 9, you learned about the Web Services Description Language (WSDL). WSDL uses terms such as *port*, *message*, *service type*, *binding*, and *service*. WCF vocabulary is similar to WSDL with a few differences. In this section, you will learn the WCF vocabulary:

- *Service model*: The model provided by WCF to build software components.
- *Channel layer*: That part of WCF that deals with low-level network programming. The classes from the channel layer are used by high-level classes of WCF.
- *Service*: A piece of software that responds to communication over a network. A service has one or more endpoints. Communication with the service is redirected to one of these endpoints.
- *Endpoint*: Where the actual request for a service is redirected. An endpoint consists of an address, a binding, and a contract.
- *Address*: Nothing but the unique location of the underlying service on a network. Clients use this address to talk with the service. An address takes the form of a Uniform Resource Locator (URL)—for example, `http://localhost:8000/MyService`.
- *Binding*: An address is just a URL where the service can be located. However, that's not enough. You also need to know the protocol used for communication such as TCP or HTTP. This is specified with the help of a binding. The binding specifies the protocol for encoding the request and response as well as the protocol for transporting them over the network.
- *Contract*: A set of operations that are exposed by the service. In other words, a contract is a set of operations available at a given endpoint. At the code level, a contract is defined with the help of an interface.
- *Service type*: A class that implements a contract.

Creating and Consuming a WCF Service

To create and consume WCF services, you essentially need to develop three pieces of software:

- One or more service types
- A host that publishes the services exposed by the service types on a network
- A client application that consumes the functionality exposed by the service types

All the core functionality of WCF is available in the `System.ServiceModel.dll` assembly.

The `System.ServiceModel` namespaces contain many classes and attributes related to WCF. So, you must reference this assembly and import the `System.ServiceModel` namespace as and when needed. In the next few sections, you learn how to develop each of the three parts.

Creating the Service

Creating a WCF service requires the following steps:

1. Define a contract for the service.
2. Implement the service contract.
3. Define the data structures (if any) to carry data from the service to the client.

Now that you have a brief idea about what's involved in creating WCF services, let's create a service.

Begin by creating a new project of type WCF Service Library named `EmployeeWCFService` (see Figure 10-1).

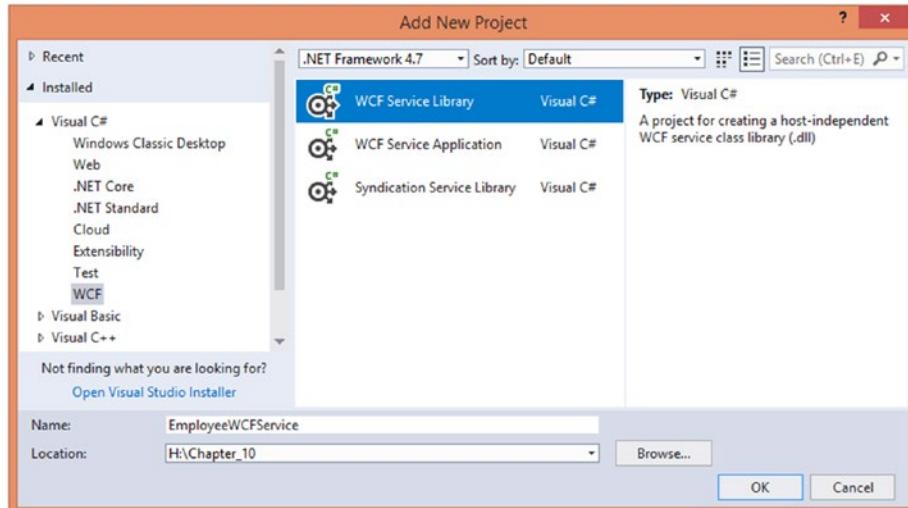


Figure 10-1. Creating a new WCF service library

Then add an interface to the project by using the Add New Item dialog box and name it `IEmployeeManager`.

Note When you create a new project of type WCF Service Library, Visual Studio adds a template for creating a new service by default. Additionally the Add New Item dialog of Visual Studio also provides a template for adding a new WCF Service. However, for the sake of clear understanding, I am not going to use the default code templates.

Import the System.ServiceModel namespace at the top of the interface file and add the code shown in Listing 10-1 in the interface.

Listing 10-1. Creating the IEmployeeManager Interface

```
using System;
using System.Collections.Generic;
using System.Text;
using System.ServiceModel;
using System.Data;

namespace EmployeeWCFService
{
    [ServiceContract]
    public interface IEmployeeManager
    {
        [OperationContract]
        List<EmployeeDataContract> SelectAll();

        [OperationContract]
        EmployeeDataContract SelectByID(int id);

        [OperationContract]
        string Update(EmployeeDataContract emp);
    }
}
```

The IEmployeeManager interface acts as a WCF contract. The IEmployeeManager interface defines three methods: SelectAll(), SelectByID(), and Update(). The SelectAll() method when implemented will return a list of all the employees from the Employees table of the Northwind database. The SelectByID() method when implemented will return details of a specific employee. The EmployeeDataContract class is defined and explained later in this section. Notice two things about the IEmployeeManager WCF contract:

- The interface must be decorated with the **[ServiceContract]** attribute. This attribute indicates that the interface decorated by it is a WCF service contract.
- Each method signature in the interface must be marked with the **[OperationContract]** attribute, which indicates that the method decorated by it will be exposed as a part of the service. Methods are referred to as *operations* in WCF.

After you define a contract, you need to implement it. You do this by creating a class that implements the contract interface. You need not do anything special with the service type apart from implementing the service contract.

In our example, the `EmployeeDataContract` class is used to carry details of an employee from the service to the client. This is the *data contract* of the service. So, add the `EmployeeDataContract` class to the project. Also add a reference to the `System.Runtime.Serialization` assembly. Then import the `System.ServiceModel` and `System.Runtime.Serialization` namespaces at the top of the `EmployeeDataContract` class. Listing 10-2 shows the complete code that makes up the `Employee` class.

Listing 10-2. The `EmployeeDataContract` Class

```
using System;
using System.Collections.Generic;
using System.Text;
using System.ServiceModel;
using System.Runtime.Serialization;
using System.Data;

namespace EmployeeWCFService
{
    [DataContract]
    public class EmployeeDataContract
    {
        [DataMember]
        public int EmployeeID { get; set; }
        [DataMember]
        public string LastName { get; set; }
        [DataMember]
        public string FirstName { get; set; }
        [DataMember]
        public string HomePhone { get; set; }
        [DataMember]
        public string Notes { get; set; }
    }
}
```

The `EmployeeDataContract` class consists of five public properties: `EmployeeID`, `FirstName`, `LastName`, `HomePhone`, and `Notes`. Notice how the class is marked with the `[DataContract]` attribute, and individual properties with the `[DataMember]` attribute. This way, the class and its state information are serialized to the client. Anytime you want to return custom objects from your service methods, you need to mark such classes with the `[DataContract]` attribute. Further, each member of the class that will be transferred to the client must be marked with the `[DataMember]` attribute. You may notice that the use of the `[DataContract]` attribute is similar to the `[Serializable]` attribute.

Note You will find this code familiar because you used `[DataContract]` and `[DataMember]` attributes in Chapter 8 while learning XML serialization.

The `EmployeeDataContract` simply defines the data contract needed by the `EmployeeManager` service. However, you need to write code that fetches the data from the Northwind database. You can, of course, use plain ADO.NET code to accomplish this task. But to save us some time and code we will use Entity Framework code-first for this purpose. To generate EF model and context, add a new folder into the project root named `Models`, right-click on it and open the Add New Item dialog. Then under the Data section, select ADO.NET Entity Data Model (Figure 10-2).

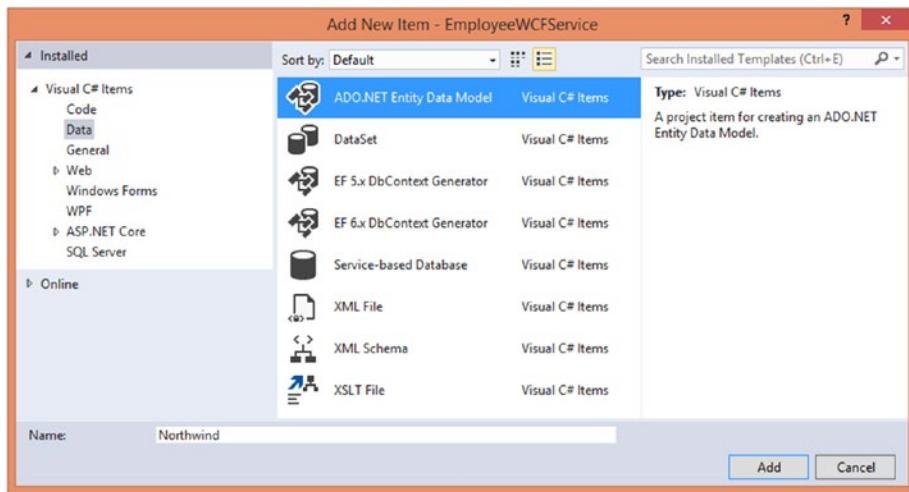


Figure 10-2. Adding ADO.NET Entity Data Model

Name and model **Northwind** and click Add. This will start a wizard. Pick **Code First** from database option (Figure 10-3) and simply follow the wizard to generate the context and entity classes.

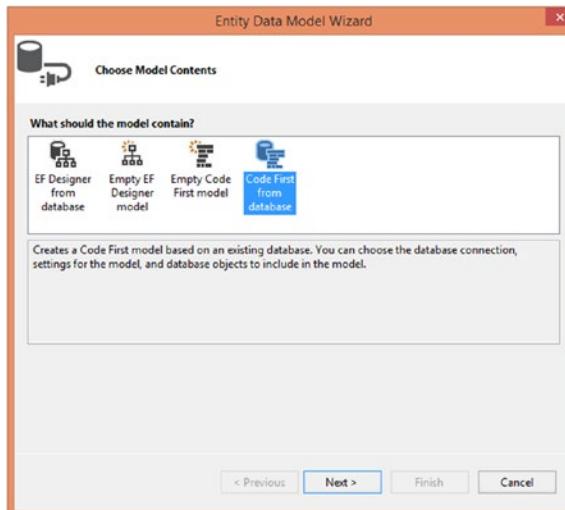


Figure 10-3. Generating a model using the code-first approach

Successful run of the wizard will add `Northwind.cs` and `Employee.cs` files to the `Models` folder. The former file contains the context class whereas the latter file contains the `Employee` entity class. Since these classes are autogenerated for you, they are not discussed here.

The last step in creating this service is to implement the service contract in a class called `EmployeeManager`. Listing 10-3 shows the complete code of the `EmployeeService` class.

Listing 10-3. The EmployeeService Class

```

public class EmployeeManager : IEmployeeManager
{
    public List<EmployeeDataContract> SelectAll()
    {
        using (Northwind db = new Northwind())
        {
            var query = from e in db.Employees
                        orderby e.EmployeeID ascending
                        select new EmployeeDataContract()
            {
                EmployeeID = e.EmployeeID,
                FirstName = e.FirstName,
                LastName = e.LastName,
                HomePhone = e.HomePhone,
                Notes = e.Notes
            };
            return query.ToList();
        }
    }
    public EmployeeDataContract SelectByID(int id)
    {
        using (Northwind db = new Northwind())
        {
            var query = from e in db.Employees
                        where e.EmployeeID == id
                        select new EmployeeDataContract()
            {
                EmployeeID = e.EmployeeID,
                FirstName = e.FirstName,
                LastName = e.LastName,
                HomePhone = e.HomePhone,
                Notes = e.Notes
            };
            return query.SingleOrDefault();
        }
    }

    public string Update(EmployeeDataContract emp)
    {
        using (Northwind db = new Northwind())
        {
            Employee existing = db.Employees.Find(emp.EmployeeID);
            existing.FirstName = emp.FirstName;
            existing.LastName = emp.LastName;
            existing.HomePhone = emp.HomePhone;
            existing.Notes = emp.Notes;
            db.SaveChanges();
            return "Employee modified successfully!";
        }
    }
}

```

The EmployeeManager class implements the `IEmployeeManager` interface. The `SelectAll()` method fills a list with all the employees and returns it to the caller. Notice that `SelectAll()` method needs to return `EmployeeDataContract` objects. This is done by mapping data from the `Employee` objects to `EmployeeDataContract` objects using the LINQ to Entities query.

The `SelectByID()` method accepts an employee ID. It then fetches details of that employee from the database using LINQ to Entities query. The `EmployeeDataContract` object is then returned to the caller.

The `Update()` method accepts an `EmployeeDataContract` object. Inside, it finds an existing employee based on its `EmployeeID`. The properties of the existing employee are then modified using the values from the `EmployeeDataContract`. The `SaveChanges()` method saves the changes to the database. A message is sent back to the caller indicating that the employee has been successfully modified.

Compile the `EmployeeWCFService` project so as to produce the `EmployeeWCFService.dll` assembly.

Hosting the Service

Now that you have created the service type, it's time to think about hosting it. Hosting the service will make it available on a network so that client applications can consume it. To host the service, you have multiple options. Some of them include:

- Create a console application and use it as a host.
- Host the WCF service in IIS.
- Host the WCF service in a Windows service application.

In this example, we use a console application as a host. In later sections, you learn to use IIS to host WCF services.

Add a new project of the type console application in the same solution as the service and name it `EmployeeWCFServiceHost`. See Figure 10-4.

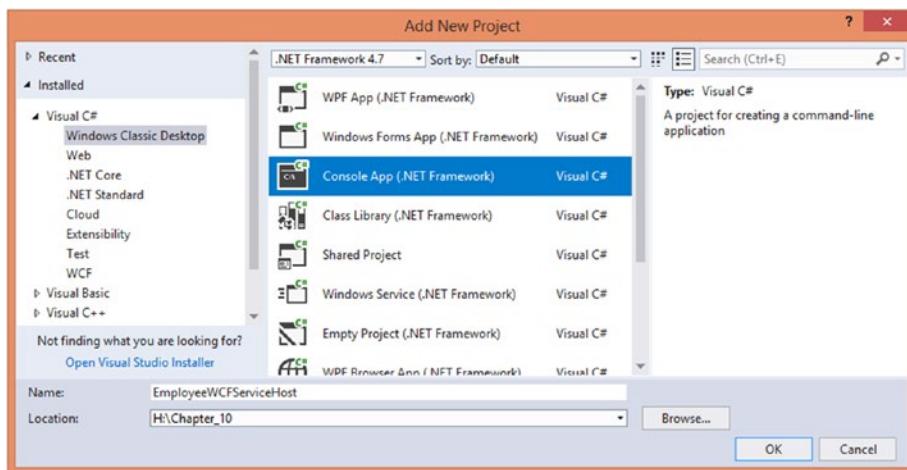


Figure 10-4. Creating a console application to host the WCF service

Add a reference to the `System.ServiceModel` and `EmployeeWCFService` assemblies. The newly created console application project will already contain an `App.config` file. Open the `App.config` file in Visual Studio Editor and enter the markup shown in Listing 10-4 inside the `<configuration>` root element.

Listing 10-4. Configuring the Service

```
<system.serviceModel>
  <services>
    <service name="EmployeeWCFService.EmployeeManager"
      behaviorConfiguration="EmployeeWCFServiceBehavior">
      <endpoint address="EmployeeManager"
        binding="basicHttpBinding"
        contract="EmployeeWCFService.IEmployeeManager">
      </endpoint>
    </service>
  </services>
  <behaviors>
    <serviceBehaviors>
      <behavior name="EmployeeWCFServiceBehavior">
        <serviceMetadata httpGetEnabled="True"/>
        <serviceDebug includeExceptionDetailInFaults="true" />
      </behavior>
    </serviceBehaviors>
  </behaviors>
</system.serviceModel>
```

The `<system.serviceModel>` section of the configuration file contains all the configuration settings related to hosting WCF services. There are two subsections: `<services>` and `<behaviors>`.

The former contains configuration information about one or more services in terms of name, endpoints, and addresses. The latter contains configuration information about behavior exhibited by the services defined in the `<services>` section. A *behavior* is a class that modifies or extends the service or client functionality. It can also modify channel settings.

Each service from the `<services>` section is configured via a `<service>` section:

- The `name` attribute specifies the fully qualified name of the service type (`EmployeeWCFService.EmployeeManager` in our case).
- The `behaviorConfiguration` attribute points to the name of the service behavior as defined in the `<serviceBehaviors>` section.
- The `<endpoint>` element details one or more endpoints where the service is available.
- The `address` attribute of the `<endpoint>` element specifies the address of the service.
- The `binding` attribute specifies the protocol to be used for communication. The two commonly used bindings are `net.tcp` for TCP and `basicHttpBinding` for HTTP. There are several other bindings provided, such as `netMsmqBinding`, `netNamedPipeBinding`, and so on.
- Finally, the `contract` attribute specifies the fully qualified name of the interface that provides the service contract (`IEmployeeManager` in our case).

In our example, we created an endpoint for HTTP-based communication.

The `<serviceBehaviors>` section contains one or more `<behavior>` elements:

- The name attribute of the `<behavior>` element specifies the name of that behavior. This name is used in the `behaviorConfiguration` attribute of the `<service>` element.
- The `<serviceMetadata>` element indicates that the metadata of the service can be retrieved by using an HTTP GET request. You will find this feature analogous to web services, where you retrieve WSDL by using a query string (that is, a GET request).

Now open the `Main()` method of the console application and type in the code shown in Listing 10-5.

Listing 10-5. Hosting the WCF Service

```
static void Main(string[] args)
{
    try
    {
        Type t = typeof(EmployeeManager);
        Uri http = new Uri("http://localhost:8000/EmployeeWCFService");
        ServiceHost host = new ServiceHost(t, tcp, http);
        host.Open();
        Console.WriteLine("Employee Manager Service Published.");
        Console.ReadLine();
        host.Close();
    }
    catch (Exception ex)
    {
        Console.WriteLine(ex.Message);
        Console.ReadLine();
    }
}
```

The code retrieves the Type of the service type class by using the `typeof()` expression. It then creates an instance of the `Uri` class pointing to the HTTP-based URL where the service is to be published. Note how the port number is set as 8000. You could use any port number but ensure that it's not used by any other applications and is not blocked on a network.

Then an instance of the `ServiceHost` class is created. The `ServiceHost` class hosts the service by publishing the service type at the specified URIs. Note that the constructor of the `ServiceHost` class takes a parameter array of URIs. In our example, we have passed two, but you can pass more if you want. The following constructor signature will make it clear:

```
public ServiceHost (Type serviceType, params Uri[] baseAddresses)
{
    ...
}
```

The `Open()` method of the `ServiceHost` class is then called. This method actually hosts the service depending on the configuration information. The service will remain published so long as the host application is live. That is why the `ReadLine()` method of the `Console` class is called. It keeps the application live until the user presses the Enter key. Finally, the `Close()` method of the `ServiceHost` class is called. This completes the host application.

Note During development, you can also use Visual Studio's built-in WCF service host, skipping the host application altogether. However, for the sake of clear understanding of all the steps involved, we won't use the built-in host in this example.

Consuming the Service

In this section, you create a client application that consumes the EmployeeWCFService we created previously. To begin, you need to create a Windows application called EmployeeWCFServiceClient, like the one shown in Figure 10-5.

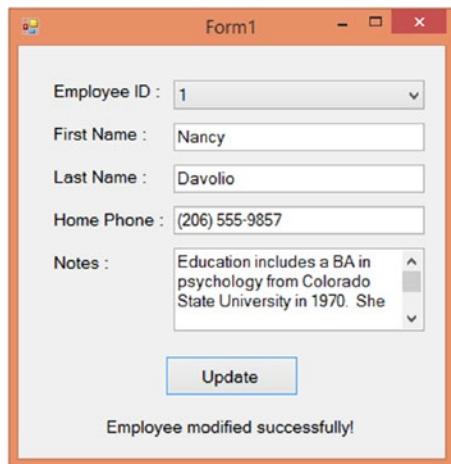


Figure 10-5. The client consuming the WCF service

The application consists of a list box containing a list of all the employees. Clicking a particular employee will display their details in text boxes placed below. You can change the details such as first name, last name, home phone and notes. Clicking on the Update button will save the changes to the database. A success message is also displayed to the user using a Label.

Before you consume the service, you should create a proxy for it. Run the service host application that you developed earlier (make sure to run the application from outside of Visual Studio so that you can complete the next step). Then right-click the client application project and choose the Add Service Reference menu option. This will open a dialog like the one shown in Figure 10-6.

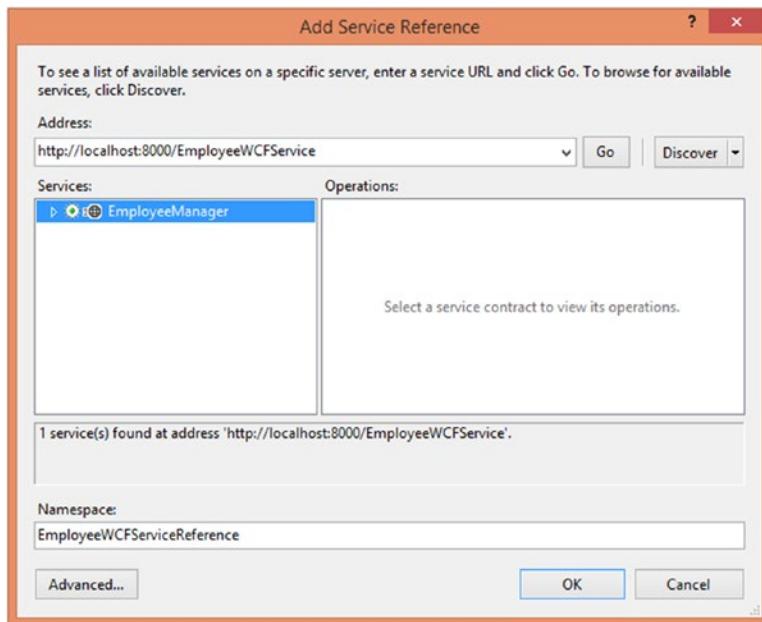


Figure 10-6. Adding a service reference

Enter the HTTP endpoint address of the WCF service (i.e., `http://localhost:8000/EmployeeWCFService`) and `EmployeeWCFServiceReference` as the namespace name for the proxy class.

This will create a service reference for the service. All the service references added to a project are listed in the Solution Explorer, as shown in Figure 10-7.

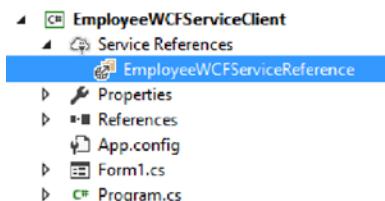


Figure 10-7. Service reference as shown in the Solution Explorer

Adding a service reference will also add some markup in the client's application configuration file. Now you can call the service from your client code. Listing 10-6 shows the Load event handler of the form.

Listing 10-6. Retrieving the List of Employees

```
private string endPoint = "BasicHttpBinding_IEmployeeManager";
private void Form1_Load(object sender, EventArgs e)
{
    EmployeeManagerClient proxy = new EmployeeManagerClient(endPoint);
    EmployeeDataContract[] data = proxy.SelectAll();
```

```

foreach(EmployeeDataContract emp in data)
{
    comboBox1.Items.Add(emp.EmployeeID);
}
proxy.Close();
}

```

The code declares a local variable—`endpoint`—to store the name of the service endpoint. You can figure out the endpoint configuration name from the client's application configuration file.

The code then creates a new instance of the proxy class. Notice how the proxy class is named `XXXXClient` (`EmployeeManagerClient` in our case), where `XXXX` is the name of the original service class. In the constructor of the proxy class, you pass the desired endpoint configuration name.

The code then calls the `SelectAll()` method on the proxy object to retrieve details of all the employees. Notice that the `SelectAll()` method called on the proxy returns an array of `EmployeeDataContract` objects. A `foreach` loop then fills the EmployeeIDs into the combo box. Finally, the underlying communication channel is closed by calling the `Close()` method of the proxy.

When a user clicks any of the employees listed in the combo box, details of that employee are to be displayed in the other text boxes. This is done in the `SelectedIndexChanged` event handler of the combo box (see Listing 10-7).

Listing 10-7. Retrieving the Details of an Employee

```

private void comboBox1_SelectedIndexChanged(object sender, EventArgs e)
{
    EmployeeManagerClient proxy = new EmployeeManagerClient(endPoint);
    EmployeeDataContract data = proxy.SelectByID((int)comboBox1.SelectedItem);
    textBox1.Text = data.FirstName;
    textBox2.Text = data.LastName;
    textBox3.Text = data.HomePhone;
    textBox4.Text = data.Notes;
    label6.Text = "";
    proxy.Close();
}

```

The code is very similar to what you saw earlier. This time it calls the `SelectByID()` method on the proxy by passing the selected `EmployeeID`. The `SelectByID()` method returns an `EmployeeDataContract` object filled with the required details. The details such as `EmployeeID`, `FirstName`, `LastName`, `HomePhone`, and `Notes` are then displayed in respective text boxes.

Once the details of an employee are displayed in the text boxes, you can change them and click on `Update` to save them to the database. The `Click` event handler of the `Update` button is shown in Listing 10-8.

Listing 10-8. Saving the Modifications to the Database

```

private void button1_Click(object sender, EventArgs e)
{
    EmployeeManagerClient proxy = new EmployeeManagerClient(endPoint);
    EmployeeDataContract data = new EmployeeDataContract();
    data.EmployeeID = (int)comboBox1.SelectedItem;
    data.FirstName = textBox1.Text;
    data.LastName = textBox2.Text;
    data.HomePhone = textBox3.Text;
}

```

```
    data.Notes = textBox4.Text;
    label6.Text=proxy.Update(data);
    proxy.Close();
}
```

The code is straightforward—it creates a proxy object as before. This time it also creates a new EmployeeDataContract object and fills it with the modified details of an employee. The Update() method of the proxy is then called in an attempt to save the changes to the database. A Label control displays the success message returned by the Update() method.

Testing the Host and Client

Now that you have coded all three parts (service, host, and client), let's test them. First, compile all the projects from the solution. Then run the host console application. If everything goes well, you should see a command prompt like the one shown in Figure 10-8.

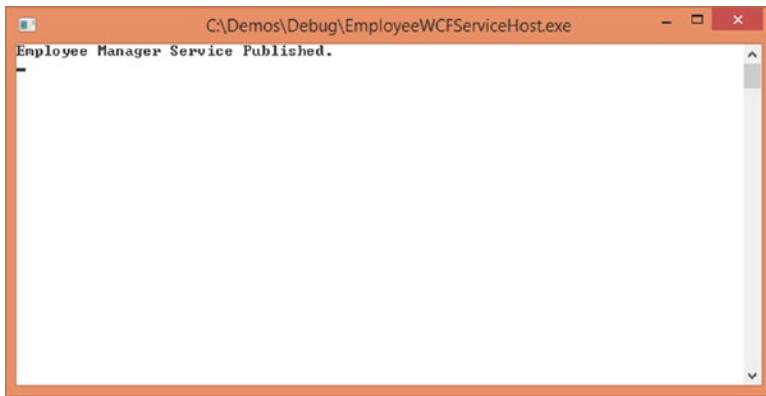


Figure 10-8. Running the host application

Next open a browser and enter the URL of the service endpoint (`http:// localhost:8000/ EmployeeWCFService`) in the address bar. You should get a web page like the one shown in Figure 10-9.

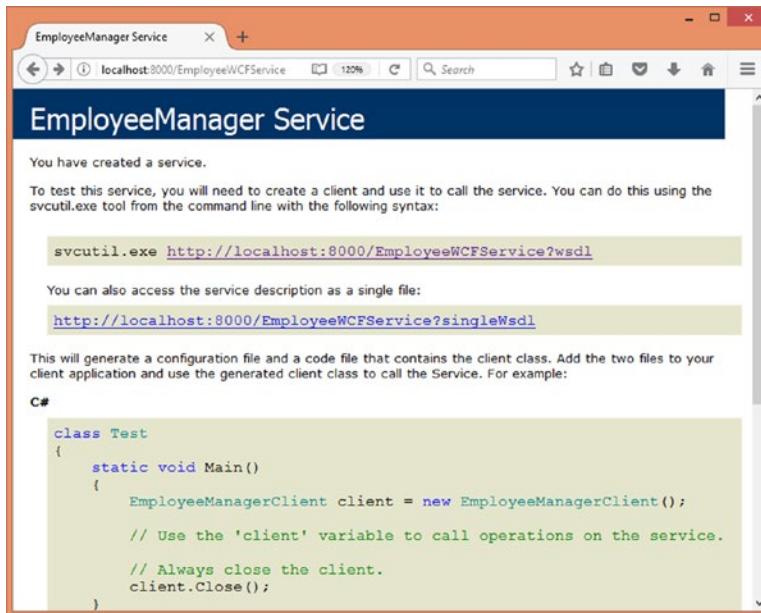


Figure 10-9. Testing to see whether the service is hosted properly

If you get this page, the service is hosted correctly. Click on the URL specified at the top of the web page, and you should see the WSDL of the service, as shown in Figure 10-10.

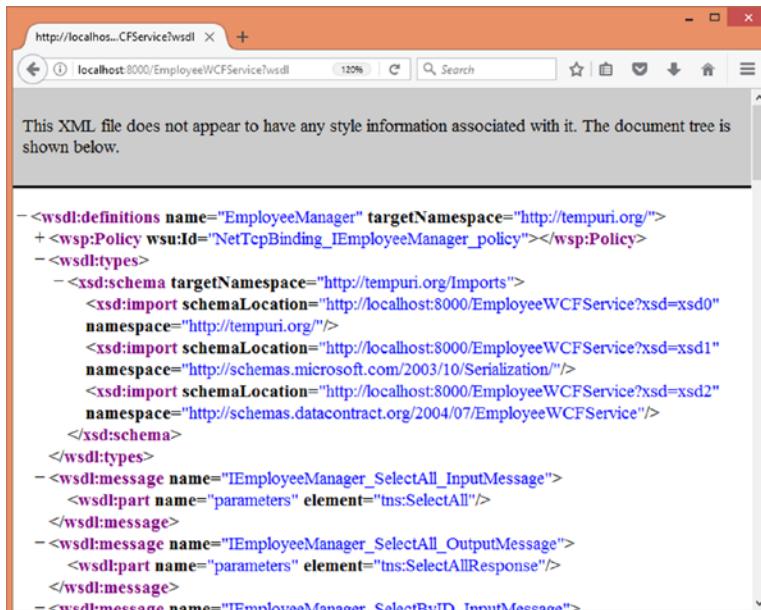


Figure 10-10. WSDL of the service

You will find this mechanism very similar to web services, where you retrieved the WSDL of a web service just by specifying the `wsdl` query string parameter.

Now run the client application, and you should see the combo box populated with the list of all the employees. Click individual employee names, and their details will be displayed in various text boxes. Also test whether any modifications to the employee details are saved in the database after clicking the Update button.

Hosting a WCF Service in IIS

In the preceding example, we used a console application to host our service. However, you can also use IIS (or Visual Studio development web server) to host a WCF services. This way, your service is automatically started when the IIS application starts, and you also get all the security features of IIS for your service.

To begin, add a new ASP.NET Web Application project to the current solution (see Figure 10-11).

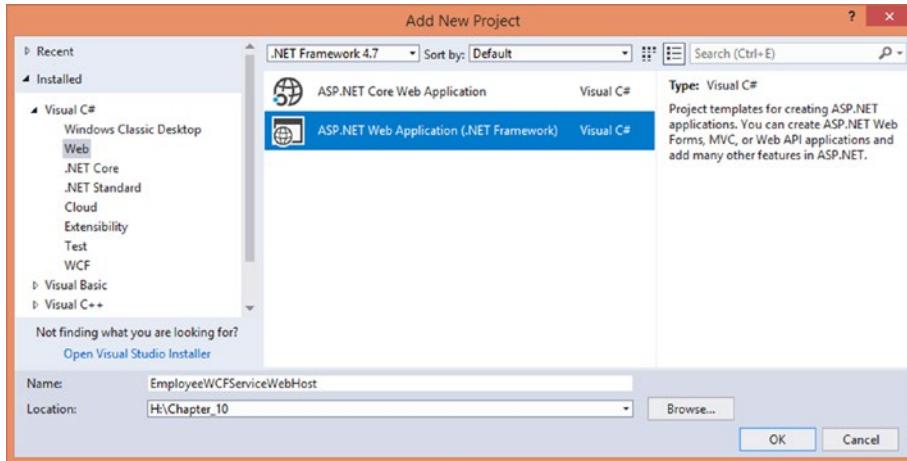


Figure 10-11. Adding a new ASP.NET web application

While creating the project, select the Empty project template, as shown in Figure 10-12.

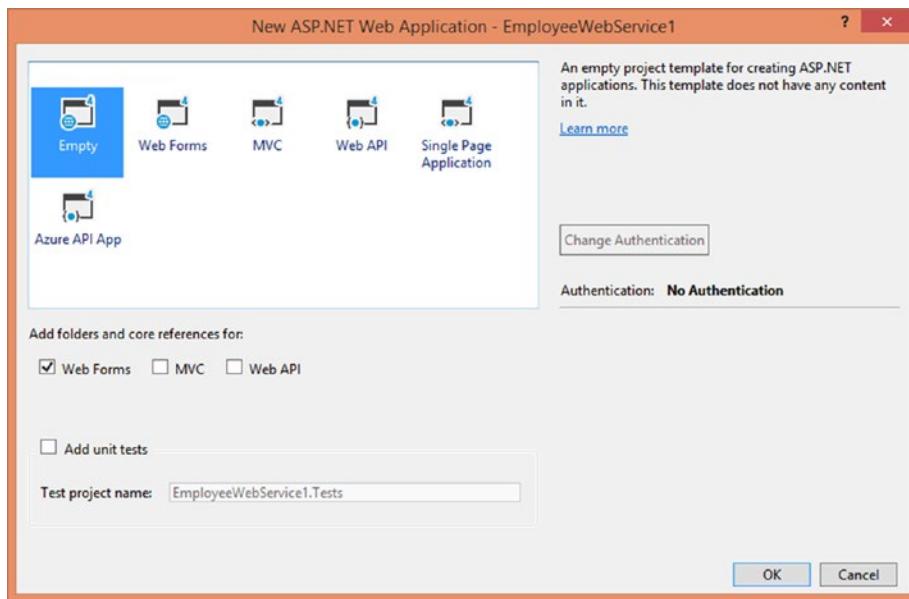


Figure 10-12. Project based on the *Empty* template

This way, you will have a project with just the basic project items such as `web.config`. Next, add a reference to the `EmployeeWCFService` assembly as you did in the earlier examples. Now, add a new WCF service to the project using the Add New Item dialog (see Figure 10-13).

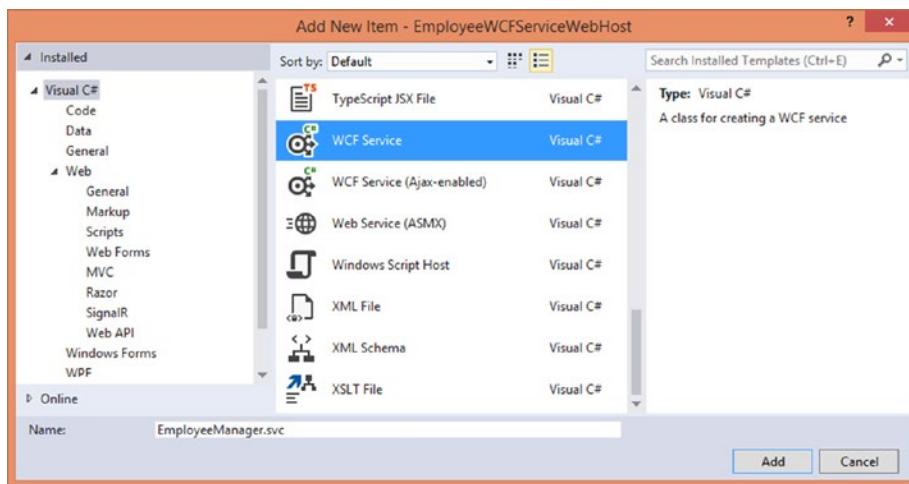


Figure 10-13. Adding a new WCF service

This will add a new .svc file to the project and also its code-behind. The .svc file contains information about the WCF service being exposed. You can delete the code-behind file because our service is already bundled in an assembly.

Then open the EmployeeManager.svc file in the Visual Studio text editor. You will find that the .svc file contains the @ServiceHost directive. Modify this directive as shown in Listing 10-9.

Listing 10-9. Adding the ServiceHost Directive

```
<%@ServiceHost Service="EmployeeWCFService.EmployeeManager" %>
```

The @ServiceHost directive indicates that the file is a WCF service host. The Service attribute specifies the fully qualified name of the service type. Now add a web.config file to the web site and type in the markup shown in Listing 10-10.

Listing 10-10. Configuring the Host

```
<system.serviceModel>
  <services>
    <service name="EmployeeWCFService.EmployeeManager"
      behaviorConfiguration="EmployeeWCFServiceBehavior">
      <endpoint address=""
        binding="basicHttpBinding"
        contract="EmployeeWCFService.IEmployeeManager">
        </endpoint>
      </service>
    </services>
    <behaviors>
      <serviceBehaviors>
        <behavior name="EmployeeWCFServiceBehavior">
          <serviceMetadata httpGetEnabled="True"/>
          <serviceDebug includeExceptionDetailInFaults="true" />
        </behavior>
      </serviceBehaviors>
    </behaviors>
  </system.serviceModel>
```

It is essentially the same markup that you specified for the console host. The only difference is that the address attribute of the <endpoint> element is an empty string. This is because for an IIS-hosted service, the address is the same as the URI of the .svc file hosting the service.

To access the EmployeeService hosted in IIS, the endpoint URL will be `http://localhost:49303/EmployeeManager.svc` (change the port number to match yours). Observe that the URL points to the .svc file. You can also append the wsdl query string parameter to extract its WSDL. Figure 10-14 shows a sample run of the .svc file in a browser.

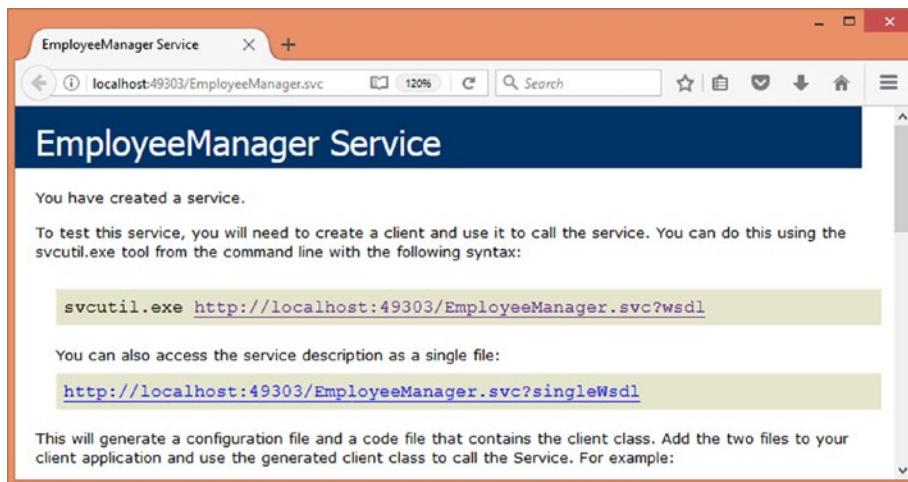


Figure 10-14. Navigating to the .svc file in a browser

You can feed this URL to the proxy generator and the proxy will be generated for you. The overall process of proxy creation and invoking the service remains the same as in the previous example.

Understanding the Role of XML in WCF Services

From what you have learned up until now, it is clear that WCF uses XML for configuring various pieces of services. However, there is more to the story.

In the preceding example that you just developed, the employee data from the EmployeeManager service magically appeared in the client application. However, how did that happen? How was the data sent on the wire? As far as basic HTTP binding is concerned, the data is serialized on the wire as a SOAP message. This means XML data in the form of a SOAP envelop is being sent to the client.

Note SOAP based communication can cause a performance penalty due to its bulky nature. However, SOAP is a natural choice when interoperability is more important for your application. WCF also allows you to use binary communication over TCP. Such a communication can give performance benefits to your application. Discussion of these details is beyond the scope of this book.

Just to understand what has just been said, go to the EmployeeWCFService project and press F5. Doing so will open WCF Test Client, as shown in Figure 10-15.

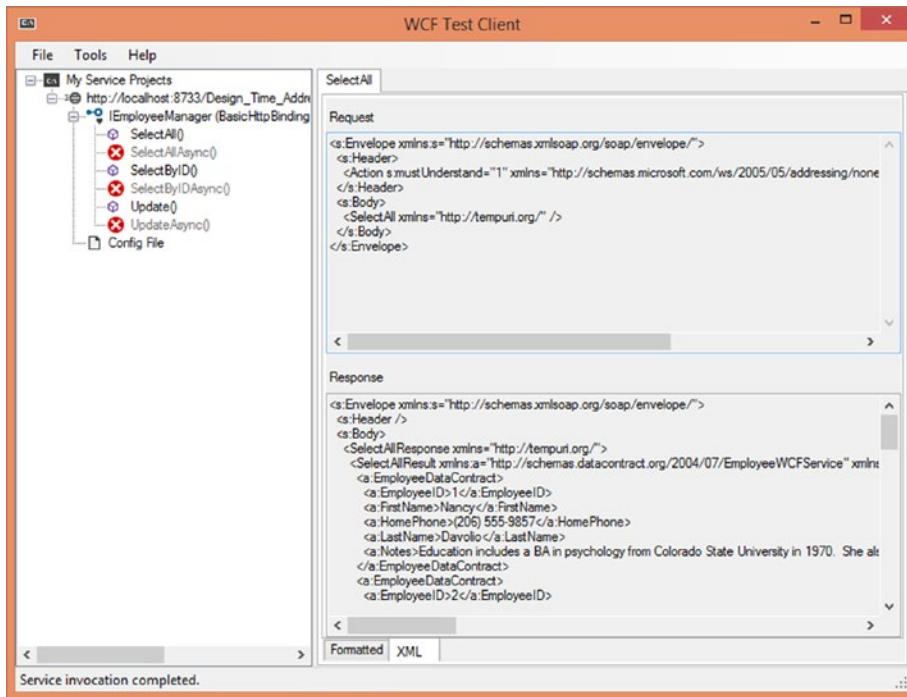


Figure 10-15. Observing a message in WCF test client

The WCF test client allows you to invoke service methods. On the left side, double-click on the `SelectAll()` method. Then click on the Invoke button on the right side of the panel. This will invoke the method and all the `EmployeeDataContract` objects will be returned. Switch to XML tab and you will see the SOAP request and SOAP response messages.

In case of WCF RESTful services (you will learn about them in later sections), the data is serialized as plain XML rather than a SOAP message.

Using XmlSerializer Instead of DataContractSerializer

The WCF framework can use two approaches while serializing the XML data:

- By default, WCF uses the `DataContractSerializer` class (an implementation of `XmlObjectSerializer`) for serializing the XML data. You already learned about the `DataContractSerializer` class in Chapter 8.
- You can also instruct WCF to use `XmlSerializer` for the XML serialization. Doing so will give you more control of how the data is serialized. You can customize the serialization process by using various attributes such as `[XmlAttribute]` and `[XmlElement]`. You already learned about the `XmlSerializer` class in Chapter 8.

To instruct the WCF framework that it should use `XmlSerializer` instead of `DataContractSerializer`, all you need to do is decorate the service contract interface with the `[XmlSerializerFormat]` attribute. The `IEmployeeManager` interface after applying the `[XmlSerializerFormat]` attribute is shown in Listing 10-11.

Listing 10-11. Applying the [XmlSerializerFormat] Attribute

```
[ServiceContract]
[XmlSerializerFormat]
public interface IEmployeeManager
{
    ...
    ...
}
```

Understanding REST Services

The WCF services we discussed so far were operations-based, in that you always explicitly invoked a specific method or operation of the service. Modern web applications often create and consume RESTful services. From our earlier discussion you know that REST services are resource-based services. Although this chapter doesn't attempt to teach you the fundamental of REST services as such, a brief discussion REST is worthwhile.

REST stands for REpresentational State Transfer. REST is not a standard; it's a way of architecting your services. Unlike ASMX web services or WCF operations-based services that use protocols and standards such as Simple Object Access Protocol (SOAP) and Web Services Description Language (WSDL), RESTful services harness the simplicity and power of HTTP.

Here are some fundamental characteristics of RESTful services:

- REST services use the HTTP protocol.
- REST services make HTTP requests (using meaningful HTTP verbs such as GET, POST, PUT, and DELETE) to fetch and submit data.
- REST services are stateless in nature.
- REST exposes services as resources that are accessible and discoverable through URLs.
- REST services typically transfer data in JSON or XML format.

As far as the .NET Framework is concerned there are two ways for creating RESTful services—WCF REST services and Web API. Nowadays, it is more common for web applications to use JSON (JavaScript Object Notation) as a format for data transfer between a service and its client, but you can use XML also. Our interest is, of course, is to see how XML can be used along with these frameworks.

The HTTP verbs such as GET, POST, PUT, and DELETE indicate the desired action to be performed on a resource. If a service performs create, read, update, and delete (CRUD) operations on a database, you could use POST to indicate an INSERT operation, GET to indicate a SELECT operation, PUT to indicate an UPDATE operation, and DELETE to indicate a DELETE operation. However, merely using a specific verb won't enforce a particular type of operation. It's up to you to implement these verbs in a service depending on application's requirements.

Now that you have an idea about what REST services are, you'll see how to create them, first using WCF and then using Web API.

Creating a REST Service Using WCF

Creating a RESTful service using WCF requires the same steps that you are familiar with. However, two major changes are:

- Since REST services use HTTP verbs to invoke methods, you use `webHttpBinding`. It is also common to host such a service in IIS or a web server (as discussed earlier).
- The mapping between HTTP verbs and service methods is specified in the service contract.

Apart from these changes, the remaining parts of a service are more or less the same as before.

Begin by creating a new ASP.NET Web Application based on the empty project template. As you did with the EmployeeWCFService project, add a Models folder and generate the Entity Framework context and entity class (`Employee`). Also add `EmployeeDataContract` class as before.

Next, add an interface—`IEmployeeManager`—to the project. The completed `IEmployeeManager` interface is shown in Listing 10-12.

Listing 10-12. `IEmployeeManager` Interface

```
[ServiceContract]
public interface IEmployeeManager
{
    [OperationContract]
    [WebGet(UriTemplate = "/employees",
        ResponseFormat = WebMessageFormat.Xml)]
    List<EmployeeDataContract> SelectAll();

    [OperationContract]
    [WebGet(UriTemplate = "/employees/{id}",
        ResponseFormat = WebMessageFormat.Xml)]
    EmployeeDataContract SelectByID(string id);

    [OperationContract]
    [WebInvoke(Method = "POST",
        UriTemplate = "/employees",
        RequestFormat = WebMessageFormat.Xml ,
        ResponseFormat = WebMessageFormat.Xml)]
    string Insert(EmployeeDataContract emp);

    [OperationContract]
    [WebInvoke(Method = "PUT",
        UriTemplate = "/employees/{id}",
        RequestFormat = WebMessageFormat.Xml,
        ResponseFormat = WebMessageFormat.Xml)]
    string Update(string id,EmployeeDataContract emp);

    [OperationContract]
    [WebInvoke(Method = "DELETE",
        UriTemplate = "/employees/{id}",
        ResponseFormat = WebMessageFormat.Xml)]
    string Delete(string id);
}
```

Observe the `IEmployeeManager` interface carefully. It looks quite similar to the previous example but with a few more operations. Now it has total five operations—`SelectAll()`, `SelectByID()`, `Insert()`, `Update()`, and `Delete()`.

The operations are decorated with the `[OperationContract]` attribute. Additionally, they have either the `[WebGet]` or `[WebInvoke]` attribute on them. These attributes come from the `System.ServiceModel.Web` namespace and indicate that the WCF service is following the REST programming model.

The `[WebGet]` attribute indicates that `SelectAll()` and `SelectByID()` are retrieval operations. The `[WebInvoke]` attribute indicates that `Insert()`, `Update()`, and `Delete()` are invoke operations.

The properties of `[WebGet]` and `[WebInvoke]` configure the REST service. These properties are discussed next:

- **Method:** The `Method` property indicates the HTTP verb that invokes an operation. Common verbs are `GET`, `POST`, `PUT`, and `DELETE`.
- **UriTemplate:** Indicates the template of the endpoint URL that is used to invoke a method. For example, `http://localhost/employees` or `http://localhost/employees/1`. Notice how the `EmployeeID` is parameterized using the `{id}` syntax. This `id` value is considered as a string and hence all the underlying operations specify `id` parameter as a string type.
- **RequestFormat:** Indicates the format of the data accompanying a request. Possible values are `Xml` and `Json` (`WebMessageFormat` enumeration).
- **ResponseFormat:** Indicates the format of the data accompanying a response. Possible values are `Xml` and `Json` (`WebMessageFormat` enumeration).

Now that the `IEmployeeManager` interface is ready, add a WCF service to the project called `EmployeeManager.svc`. The code-behind file of the `.svc` file will house the `EmployeeManager` class. This class implements the `IEmployeeManager` interface as before. The complete code of the `EmployeeManager` class is shown in Listing 10-13.

Listing 10-13. EmployeeManager Class Implements `IEmployeeManager`

```
public class EmployeeManager:IEmployeeManager
{
    public List<EmployeeDataContract> SelectAll()
    {
        using (Northwind db = new Northwind())
        {
            var query = from e in db.Employees
                        orderby e.EmployeeID ascending
                        select new EmployeeDataContract()
            {
                EmployeeID = e.EmployeeID,
                FirstName = e.FirstName,
                LastName = e.LastName,
                HomePhone = e.HomePhone,
                Notes = e.Notes
            };
            return query.ToList();
        }
    }
}
```

```
public EmployeeDataContract SelectByID(string id)
{
    using (Northwind db = new Northwind())
    {
        int empId = int.Parse(id);
        var query = from e in db.Employees
                    where e.EmployeeID == empId
                    select new EmployeeDataContract()
                    {
                        EmployeeID = e.EmployeeID,
                        FirstName = e.FirstName,
                        LastName = e.LastName,
                        HomePhone = e.HomePhone,
                        Notes = e.Notes
                    };
        return query.SingleOrDefault();
    }
}

public string Insert(EmployeeDataContract obj)
{
    using (Northwind db = new Northwind())
    {
        Employee emp = new Employee();
        Emp.EmployeeID = obj.EmployeeID;
        emp.FirstName = emp.FirstName;
        emp.LastName = emp.LastName;
        emp.HomePhone = emp.HomePhone;
        emp.Notes = emp.Notes;
        db.Employees.Add(emp);
        db.SaveChanges();
        return "Employee added successfully!";
    }
}

public string Update(string id,EmployeeDataContract obj)
{
    using (Northwind db = new Northwind())
    {
        Employee emp = db.Employees.Find(int.Parse(id));
        emp.FirstName = obj.FirstName;
        emp.LastName = obj.LastName;
        emp.HomePhone = obj.HomePhone;
        emp.Notes = obj.Notes;
        db.SaveChanges();
        return "Employee modified successfully!";
    }
}

public string Delete(string id)
{
    using (Northwind db = new Northwind())
```

```
        {
            Employee emp = db.Employees.Find(int.Parse(id));
            db.Employees.Remove(emp);
            db.SaveChanges();
            return "Employee deleted successfully!";
        }
    }
}
```

This implementation should be familiar to you because `SelectAll()`, `SelectByID()`, and `Update()` are quite similar to the previous example.

The `Insert()` method accepts a new `EmployeeDataContract` object and constructs a new employee from it. It then adds the newly created employee to the `Employees` `DbSet`. The `SaveChanges()` method saves the data to the database.

The Delete() method accepts an EmployeeID to be deleted. Inside, it finds that employee and removes them from the Employees DbSet using Remove() method. The SaveChanges() method saves the changes to the database.

Now, open the `web.config` file and add the configuration shown in Listing 10-14.

Listing 10-14. Configuring of the EmployeeManager Service

```
<system.serviceModel>
  <services>
    <service name="EmployeeWCFServiceREST.EmployeeManager"
      behaviorConfiguration="EmployeeWCFServiceRESTBehavior">
      <endpoint address=""
        binding="webHttpBinding"
        contract="EmployeeWCFServiceREST.IEmployeeManager"
        behaviorConfiguration="web">
      </endpoint>
    </service>
  </services>

  <behaviors>
    <serviceBehaviors>
      <behavior name="EmployeeWCFServiceRESTBehavior">
        <serviceMetadata httpGetEnabled="true" httpsGetEnabled="true" />
        <serviceDebug includeExceptionDetailInFaults="false" />
      </behavior>
      <behavior>
        <serviceMetadata httpGetEnabled="true" httpsGetEnabled="true" />
        <serviceDebug includeExceptionDetailInFaults="false" />
      </behavior>
    </serviceBehaviors>
    <endpointBehaviors>
      <behavior name="web">
        <webHttp/>
      </behavior>
    </endpointBehaviors>
  </behaviors>
</system.serviceModel>
```

This configuration is quite similar to what you used in the previous host applications. The main difference is it uses `webHttpBinding` binding rather than `basicHttpBinding`.

This completes the EmployeeManager REST service. And now it's time to consume it from a client application.

Creating a Client That Consumes the EmployeeManager REST Service

The client application that consumes the EmployeeManager REST service will be a Windows Forms application. This application is shown in Figure 10-16.

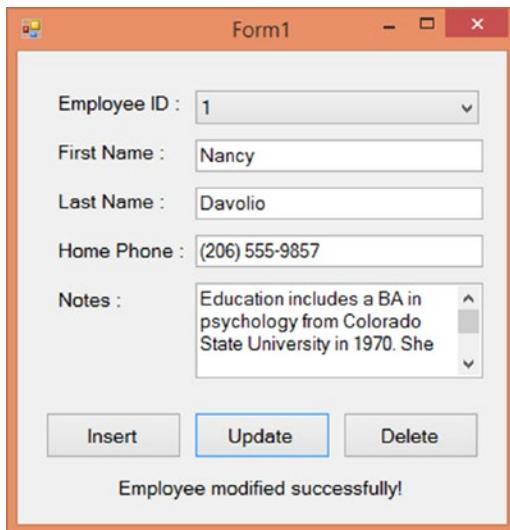


Figure 10-16. Client application consuming the REST service

The client application looks quite similar to the one you developed in the earlier example. But now it has two more buttons—Insert and Delete—for invoking the respective operations. Entering details of a new employee except EmployeeID and clicking the Insert button adds that employee. Since EmployeeID is an identity column, you don't need to specify it from the user interface. Selecting an EmployeeID from the combo box and clicking on the Delete button deletes that employee. The success message returned from insert, update, and delete operations is displayed in a Label control placed below the buttons.

Although the client application's user interface resembles the previous example, the internal workings are totally different. Previously you created a proxy in the client application and then invoked the desired methods on the proxy. That was alright since the service was operations-based. Now this client application wants to consume a REST service. Here, HTTP verbs decide what methods of the service are to be invoked. So, no proxy generation is necessary. Instead, this application will use the `HttpClient` component from the `System.Net.Http` namespace. Let's see how.

The Load event handler of the form is shown in Listing 10-15.

Listing 10-15. Getting Employee Data When the Form Loads

```

private HttpClient client;

private void Form1_Load(object sender, EventArgs e)
{
    client = new HttpClient();
    client.BaseAddress = new Uri("http://localhost:49833");
    client.DefaultRequestHeaders.Accept.Add(new MediaTypeWithQualityHeaderValue
    ("application/xml"));
    HttpResponseMessage response = client.GetAsync("/EmployeeManager.svc/employees").Result;
    string xmlData = response.Content.ReadAsStringAsync().Result;
    XmlDocument doc = new XmlDocument();
    doc.LoadXml(xmlData);
    XmlNodeList list = doc.GetElementsByTagName("EmployeeID");
    foreach(XmlNode item in list)
    {
        comboBox1.Items.Add(item.InnerText);
    }
}

```

The code declares an `HttpClient` variable—`client`—for calling the REST service. Since we want to call the services from multiple places, this object is created at form level rather than a local variable of the event handler.

The Load event handler instantiates the `HttpClient` and sets its `BaseAddress` property to the base URL, where the REST service is located. In our case this is the URL of the web application where we added the `EmployeeManager.svc` file. Make sure to change the port number as per your setup. You can easily get this URL by viewing the `.svc` file in a browser.

The next line adds the `Accept` header to the `DefaultRequestHeaders` collection. The `Accept` header value of `application/xml` means the service should return data in XML format.

Then the code calls the `SelectAll()` of the service. Notice that nowhere the operation name is mentioned. The code uses the `GetAsync()` method of the `HttpClient` object and specifies the endpoint URL of the service. Recollect that `IEmployeeManager` specifies this `UriTemplate`. The `GetAsync()` method uses `GET` verb to make the request. All the methods of `HttpClient` are asynchronous in nature. Accessing the `Result` property blocks the current thread until the method completes.

The `GetAsync()` method returns `HttpResponseMessage`—an object that wraps the actual return value. To grab the actual value, you use the `ReadAsStringAsync()` method. The `ReadAsStringAsync()` method returns the XML representation of the data returned by the REST service. This XML fragment is then loaded in an `XmlDocument`. Since we want to fill the combo box with `EmployeeID` values, all the `<EmployeeID>` elements are retrieved using the `GetElementsByTagName()` method. A `foreach` loop iterates through the retrieved elements and fills the combo box as desired.

If you observe the `xmlData` string variable in the Quick Watch window of Visual Studio, you will see XML markup as shown in Listing 10-16.

Listing 10-16. REST Service Returns Data in XML Format

```

<ArrayOfEmployeeDataContract xmlns="http://schemas.datacontract.org/2004/07/
EmployeeWCFServiceREST" xmlns:i="http://www.w3.org/2001/XMLSchema-instance">
<EmployeeDataContract>
<EmployeeID>1</EmployeeID>
<FirstName>Nancy</FirstName>
<HomePhone>(206) 555-9857</HomePhone>

```

```

<LastName>Davolio</LastName>
<Notes>Education includes a BA in psychology from Colorado State University in
1970. She also completed "The Art of the Cold Call." Nancy is a member of Toastmasters
International.</Notes>
</EmployeeDataContract>
....
....
</ArrayOfEmployeeDataContract>
```

Note Here we use the raw XML returned by the WCF REST service. If you want, you can load this XML data into Employee/EmployeeDataContract objects in the client application (you will need to create these classes in the client application). This way, the client application can process these objects as needed. We won't do that here because our primary interest is to see how the XML data format is used by these frameworks.

Okay, now let's see how SelectByID() can be called in the SelectedIndexChanged event handler of the combo box (see Listing 10-17).

Listing 10-17. Calling the SelectByID() Method

```

private void comboBox1_SelectedIndexChanged(object sender, EventArgs e)
{
    HttpResponseMessage response = client.GetAsync("/EmployeeManager.svc/employees/" +
        comboBox1.SelectedItem.Result;
    string xmlData = response.Content.ReadAsStringAsync().Result;
    XmlDocument doc = new XmlDocument();
    doc.LoadXml(xmlData);
    textBox1.Text = doc.GetElementsByTagName("FirstName")[0].InnerText;
    textBox2.Text = doc.GetElementsByTagName("LastName")[0].InnerText;
    textBox3.Text = doc.GetElementsByTagName("HomePhone")[0].InnerText;
    textBox4.Text = doc.GetElementsByTagName("Notes")[0].InnerText;
    label6.Text = "";
}
```

This code is similar to the previous listing. However, the GetAsync() method also passes an EmployeeID in the URL. This way SelectByID() method of the REST service is called. The remaining code simply reads the returned XML data and fills various text boxes with FirstName, LastName, HomePhone and Notes values.

The Click event handler of the Insert button is responsible for calling the Insert() method of the REST service. This event handler is shown in Listing 10-18.

Listing 10-18. Calling the Insert() Method of the REST Service

```

private void button1_Click(object sender, EventArgs e)
{
    string xmlEmp = "<EmployeeDataContract xmlns='http://schemas.datacontract.org/2004/07/EmployeeWCFServiceREST' xmlns:i='http://www.w3.org/2001/XMLSchema-instance'><FirstName>{textBox1.Text}</FirstName><HomePhone>{textBox3.Text}</HomePhone><LastName>{textBox2.Text}</LastName><Notes>{textBox4.Text}</Notes></EmployeeDataContract>";

    HttpContent content = new StringContent(xmlEmp, Encoding.UTF8, "application/xml");

    HttpResponseMessage response = client.PostAsync("/EmployeeManager.svc/employees", content).Result;

    string xmlMsg = response.Content.ReadAsStringAsync().Result;

    XmlDocument doc = new XmlDocument();
    doc.LoadXml(xmlMsg);
    label6.Text = doc.DocumentElement.InnerText;
}

```

We have configured the REST service to use XML format for the request as well as the response. While adding an employee, we first need to form an XML fragment that represents an `EmployeeDataContract` object. This is done by creating an XML fragment as shown. The XML fragment basically creates a `<EmployeeDataContract></EmployeeDataContract>` element with four child elements—`<FirstName>`, `<LastName>`, `<HomePhone>`, and `<Notes>`. The values of these child elements are set from the respective text boxes. As you can see, the name of the root element matches the name of the data contract class and the names of the child elements correspond to the names of the data members.

Then the XML fragment is wrapped inside a `StringContent` object. And then `PostAsync()` method of `HttpClient` is called. The `PostAsync()` method makes a POST request to the specified service. The `StringContent` object containing the employee details also accompanies the request.

The `Insert()` method of the service returns a success message. This message is unpacked from `HttpResponseMessage` using the `ReadAsStringAsync()` method. This message is then displayed in a `Label` control.

The Client event handler of the Update button is similar and is shown in Listing 10-19.

Listing 10-19. Calling the Update() Method of the REST Service

```

private void button2_Click(object sender, EventArgs e)
{
    string xmlEmp = "<EmployeeDataContract xmlns='http://schemas.datacontract.org/2004/07/EmployeeWCFServiceREST' xmlns:i='http://www.w3.org/2001/XMLSchema-instance'><EmployeeID>{comboBox1.SelectedItem}</EmployeeID><FirstName>{textBox1.Text}</FirstName><HomePhone>{textBox3.Text}</HomePhone><LastName>{textBox2.Text}</LastName><Notes>{textBox4.Text}</Notes></EmployeeDataContract>";

    HttpContent content = new StringContent(xmlEmp, Encoding.UTF8, "application/xml");

    HttpResponseMessage response = client.PutAsync("/EmployeeManager.svc/employees/" + comboBox1.SelectedItem, content).Result;

```

```

string xmlMsg = response.Content.ReadAsStringAsync().Result;

 XmlDocument doc = new XmlDocument();
 doc.LoadXml(xmlMsg);
 label6.Text = doc.DocumentElement.InnerText;
}

```

The main difference here is that `PutAsync()` method of `HttpClient` has been called. Doing so makes a `PUT` request to the service. The request URL also includes the `EmployeeID` to be modified.

Finally, the `Click` event handler of the `Delete` button does the job of calling the `Delete()` method of the service and is shown in Listing 10-20.

Listing 10-20. Calling `Delete()` Method of the REST Service

```

private void button3_Click(object sender, EventArgs e)
{
    HttpResponseMessage response = client.DeleteAsync("/EmployeeManager.svc/employees/" +
        comboBox1.SelectedItem).Result;
    string xmlMsg = response.Content.ReadAsStringAsync().Result;
    XmlDocument doc = new XmlDocument();
    doc.LoadXml(xmlMsg);
    label6.Text = doc.DocumentElement.InnerText;
}

```

Here, the code calls the `DeleteAsync()` method of `HttpClient`. The `EmployeeID` to be deleted is passed as a part of the URL.

This completes the client application. Run the client and see whether the combo box gets filled with the existing `EmployeeID` values. Also try adding, modifying, and deleting employees to confirm the workings of the `EmployeeManager` REST service.

Creating a REST Service Using Web API

Now that you know what it takes to create a REST service using WCF, let's see how Web API can be put to use for that purpose. In this section, you create a Web API service that exposes the CRUD functionality just as the WCF service you created in the previous section. A Windows Forms-based client application then consumes the service.

Begin by creating a new ASP.NET web application based on the Web API project template (see Figure 10-17).

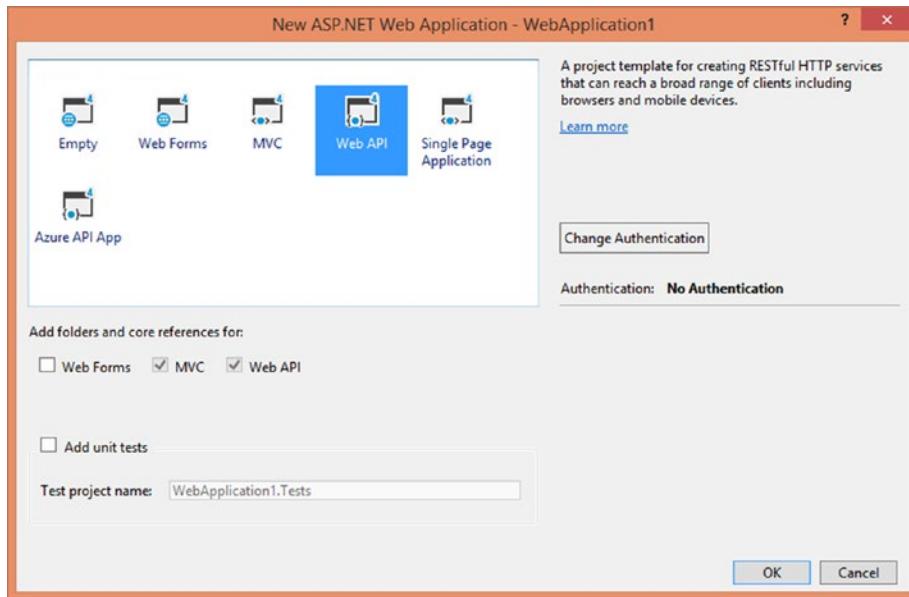


Figure 10-17. Creating a project based on Web API template

The newly created project contains a Web API service. Rename that service (file as well as the class) to EmployeeManagerController. Next, generate the Entity Framework model for the Employees table of the Northwind database, as you did in the previous examples.

Open the EmployeeManagerController in the Visual Studio Editor. You will notice that the EmployeeManagerController class inherits from ApiController. Then write the actions that perform the CRUD operations in the EmployeeManagerController. The skeleton of these actions is shown in Listing 10-21.

Listing 10-21. Skeleton of the Web API Service

```
public class EmployeeManagerController : ApiController
{
    [HttpGet]
    public List<Employee> SelectAll()
    {
    }

    [HttpGet]
    public Employee SelectByID(int id)
    {
    }

    [HttpPost]
    public string Insert(Employee obj)
    {
    }
}
```

```
[HttpPut]
public string Update(int id, Employee obj)
{
}

[HttpDelete]
public string Delete(int id)
{
}
}
```

There are five methods in all—`SelectAll()`, `SelectByID()`, `Insert()`, `Update()`, and `Delete()`. These methods should look familiar to you because the WCF REST service also had them. But there are a few differences:

- The Web API service uses `Employee` objects. We didn't create a formal data contract here. You could have done that if required, but in Web API you don't need attributes such as `[DataContract]` and `[DataMember]`.
- The Web API actions are decorated with certain attributes that map them to an HTTP verb. For example, the `[HttpPost]` added on top of `Insert()` action indicates that POST requests will be mapped to the `Insert()` action. You can avoid decorating the actions with these attributes if you follow the default naming convention—the action name begins with the HTTP verb it handles. For example, `Get()` is automatically mapped to the GET verb, `Post()` is automatically mapped to the POST verb, and so on.

The inside code of these actions is very similar to the `EmployeeManager` WCF service. So, we won't discuss all of them here. For the sake of clarity, only `SelectAll()` and `Post()` are shown in Listing 10-22.

Listing 10-22. The `SelectAll()` and `Post()` Web API Actions

```
[HttpGet]
public List<Employee> SelectAll()
{
    using (Northwind db = new Northwind())
    {
        var query = from e in db.Employees
                    orderby e.EmployeeID ascending
                    select e;
        return query.ToList();
    }
}

[HttpPost]
public string Insert(Employee obj)
{
    using (Northwind db = new Northwind())
    {
        Employee emp = db.Employees.Find(obj.EmployeeID);
        emp.FirstName = emp.FirstName;
        emp.LastName = emp.LastName;
        emp.HomePhone = emp.HomePhone;
        emp.Notes = emp.Notes;
    }
}
```

```

        db.Employees.Add(emp);
        db.SaveChanges();
        return "Employee added successfully!";
    }
}

```

Unlike WCF, Web API doesn't require any host configuration to be added to `web.config`. That's the benefit of the simple programming model offered by Web API.

Creating a Client That Consumes the EmployeeManager Web API Service

The client application that consumes the Web API is quite similar to the WCF client application you created earlier and is shown in Figure 10-18.

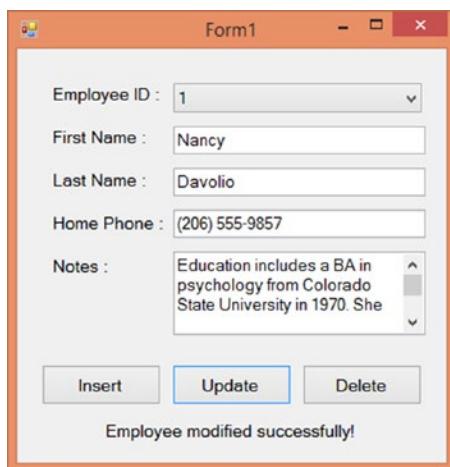


Figure 10-18. Client application that calls the Web API

Although the client application is quite similar to what you developed earlier, there are two differences:

- The endpoint URL to the REST service will now change and will follow the Web API conventions.
- Since the Web API is now returning and accepting `Employee` objects, the XML data received and sent from the client will be wrapped inside an `<Employee>` element.

To understand how these changes are reflected in the code, Listing 10-23 shows the Load event handler of the form.

Listing 10-23. Load Event Handler Receives Employee Objects in XML Format

```

private void Form1_Load(object sender, EventArgs e)
{
    client = new HttpClient();
client.BaseAddress = new Uri("http://localhost:49443");
    client.DefaultRequestHeaders.Accept.Add(new MediaTypeWithQualityHeaderValue("application/xml"));

HttpResponseMessage response = client.GetAsync("/api/EmployeeManager").Result;
string xmlData = response.Content.ReadAsStringAsync().Result;

 XmlDocument doc = new XmlDocument();
 doc.LoadXml(xmlData);

 XmlNodeList list = doc.GetElementsByTagName("EmployeeID");
 foreach(XmlNode item in list)
 {
    comboBox1.Items.Add(item.InnerText);
 }

}

```

Notice the lines marked in bold. The `BaseAddress` property now points to the address of Web API application. You should change the port number as per your setup.

The second bold line specifies the URL of the Web API. Notice that the URL takes the form /`api/<api_controller>`. This pattern comes from the default route of Web API and you can change it in the `WebApiConfig.cs` file of the Web API project.

If you observe the `xmlData` returned from the Web API, you should see something like this:

```

<ArrayOfEmployee xmlns:i="http://www.w3.org/2001/XMLSchema-instance" xmlns="http://schemas.
datacontract.org/2004/07/EmployeeWebAPIService.Models">
<Employee>
<EmployeeID>1</EmployeeID>
<FirstName>Nancy</FirstName>
<HomePhone>(206) 555-9857</HomePhone>
<LastName>Davolio</LastName>
<Notes>Education includes a BA in psychology from Colorado State University in 1970.
She also completed "The Art of the Cold Call." Nancy is a member of Toastmasters
International.</Notes>
</Employee>
....</ArrayOfEmployee>

```

As you can see, the employee details are now wrapped inside an `<Employee>` element.

This also means that during POST and PUT operations, you should send the data wrapped inside an `<Employee>` element. For example, consider the code shown in Listing 10-24, which shows the Click event handler of the Update button.

Listing 10-24. Calling PutAsync() to Modify an Employee

```
private void button2_Click(object sender, EventArgs e)
{
    string xmlEmp = $"<Employee xmlns='http://schemas.datacontract.org/2004/07/
EmployeeWebService.Models' xmlns:i='http://www.w3.org/2001/XMLSchema-instance'>
<EmployeeID>{comboBox1.SelectedItem}</EmployeeID><FirstName>{textBox1.Text}
</FirstName><HomePhone>{textBox3.Text}</HomePhone><LastName>{textBox2.Text}
</LastName><Notes>{textBox4.Text}</Notes></Employee>";

HttpContent content = new StringContent(xmlEmp, Encoding.UTF8, "application/xml");
HttpResponseMessage response = client.PutAsync("/api/EmployeeManager/" + comboBox1.
SelectedItem, content).Result;
string xmlMsg = response.Content.ReadAsStringAsync().Result;
XmlDocument doc = new XmlDocument();
doc.LoadXml(xmlMsg);
label6.Text = doc.DocumentElement.InnerText;
}
```

The modified employee details are now wrapped inside the <Employee> element along with the namespace details.

Other event handlers are not discussed here since they are quite similar to the previous examples. Just take care of these couple of differences and complete them on your own (or grab them from the book's source code).

Once the client application is ready, run the application and test whether CRUD operations work as expected.

Using XmlSerializer Instead of DataContractSerializer

Just like WCF services, Web API also uses DataContractSerializer for the sake of performing XML serialization. If you want to use XmlSerializer instead, you need to configure the Web API accordingly.

To configure the Web API to use XmlSerializer instead of DataContractSerializer, open the WebApiConfig.cs file from the App_Start folder. Then add the code shown in Listing 10-25.

Listing 10-25. Configuring Web API to Use XmlSerializer

```
public static void Register(HttpConfiguration config)
{
    config.MapHttpAttributeRoutes();
config.Formatters.XmlFormatter.UseXmlSerializer = true;
    config.Routes.MapHttpRoute(
        name: "DefaultApi",
        routeTemplate: "api/{controller}/{id}",
        defaults: new { id = RouteParameter.Optional }
    );
}
```

Notice the code shown in bold. The UseXmlSerializer property of the XmlFormatter (XmlFormatter is an object of XmlMediaTypeFormatter) is set to true. Since the Web API is now configured to use XmlSerializer, you no longer need to specify those data contract XML namespaces while sending data to the Web API.

Summary

This chapter introduced you to two service development frameworks—Windows Communication Foundation (WCF) and Web API. WCF allows you to develop operations-based as well as resource-based REST services. On the other hand, Web API allows you to build resource based REST services. WCF and Web API can deal with variety of data formats, although JSON and XML are quite popular these days. Our interest was to see how data can be sent and received in XML format using these frameworks.

Creating an operations-based WCF service involves three pieces—service, host, and client application. The client application generates a proxy for the service to invoke its operations. WCF uses XML configuration for configuring the service. Moreover, WCF uses SOAP messages to pass the data over HTTP.

Creating a REST service using WCF and Web API involves two pieces—service and the client application. Both of these frameworks can use XML format for transferring the data over the wire. The client application doesn't create any proxy, rather it calls the service directly using `HttpClient`. A simple way to access the XML data returned by a REST service is to load it in `XmlDocument`.

CHAPTER 11



XML in SQL Server

Most business applications store data in some kind of datastore, which is usually a relational database. To that end, SQL Server is one of Microsoft's flagship products. Since many applications rely on the XML data, that Microsoft found it necessary to incorporate strong support for XML in their database engine.

Because SQL Server is such a popular database, it is worth learning its XML features. Moreover, it would be interesting to see how these features can be consumed from the applications built on top of the .NET Framework. In this chapter, you learn about the following:

- Using XML extensions to the SELECT statement of the SQL Server
- Using SQLXML managed classes
- Working with the new XML data type

You should note, however, that an extensive examination of all the XML features of SQL Server is out of the scope of this book. The intention here is to make you familiar with the XML capabilities of SQL Server.

Note I used SQL Server 2012 Developer Edition to develop the examples of this chapter. Many of the examples should work with earlier versions (such as SQL Server 2010) of the product also, but I suggest you install the latest versions to avoid any mismatch. You'll also need to install the SQLXML managed classes. You can download SQLXML from Microsoft's official web site.

Using XML Extensions to the SELECT Statement

In SQL Server, you can execute SELECT statements that return the results in XML format. In Chapter 7, you got a taste of this feature while using the `ExecuteXmlReader()` method of the `SqlCommand` class. Now it's time to look at these extensions in detail.

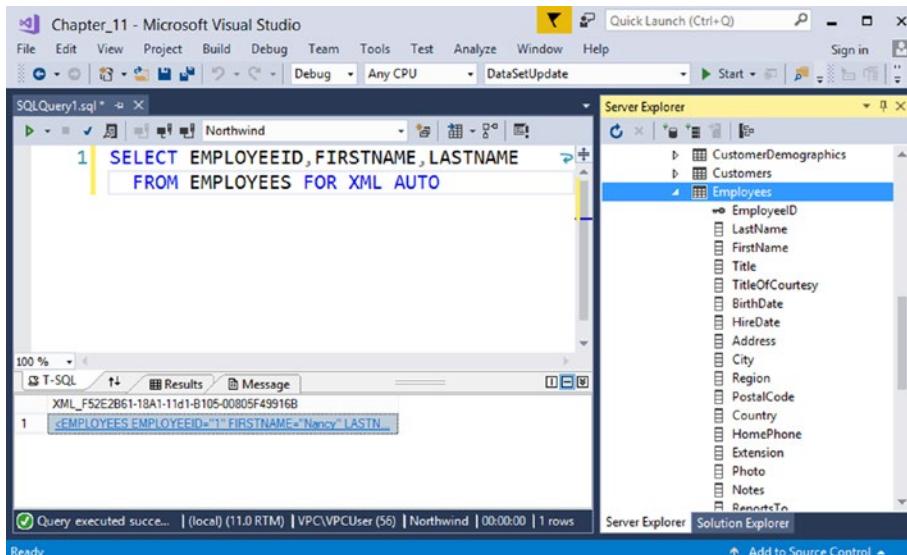
The FOR XML Clause

To fetch the FOR XML clause SQL Server data in XML format, you need to use the FOR XML clause with the SELECT statement. The FOR XML clause has four modes that allow you to return the XML results in different formats. The modes of the FOR XML clause are listed in Table 11-1.

Table 11-1. Modes of the FOR XML Clause

Mode	Description
AUTO	Returns the results of the SELECT query as XML fragments. By default it returns the data as XML elements. The name of the XML element is the same as the table name, and column values are returned as XML attributes. You have the option to return all the columns as elements instead of attributes.
RAW	Returns the results as a <row> element. The column values are returned as XML attributes.
PATH	Allows you to define the nesting of the returned XML by using simple XPath syntax.
EXPLICIT	Defines a schema for the returned results explicitly in the SELECT query.

To test these modes of the FOR XML clause, you will execute some SELECT queries against the Northwind database. To execute the queries, you can either use SQL Server Management Studio or Server Explorer of Visual Studio (shown in Figure 11-1).

**Figure 11-1.** The Server Explorer of Visual Studio with Query window

The AUTO Mode

Open SQL Server Management Studio and issue the SELECT statement shown in Listing 11-1.

Listing 11-1. Using the AUTO Mode of the FOR XML Clause

```
SELECT EMPLOYEEID,FIRSTNAME,LASTNAME FROM EMPLOYEES FOR XML AUTO
```

```
<EMPLOYEES>
<EMPLOYEE>
<EMPLOYEEID>"1"<FIRSTNAME>"Nancy"<LASTNAME>"Davolio"/>
<EMPLOYEE>
<EMPLOYEEID>"2"<FIRSTNAME>"Andrew"<LASTNAME>"Fuller"/>
<EMPLOYEE>
<EMPLOYEEID>"3"<FIRSTNAME>"Janet"<LASTNAME>"Leverling"/>
```

The SELECT statement from Listing 11-1 selects three columns—EmployeeID, FirstName, and LastName—from the Employees table. Listing 11-1 also shows the returned data in XML format. Notice how the table name is used for the XML element names (<EMPLOYEES>), and column names are used for attribute names.

Have you noticed something about the character casing of the returned XML? It depends totally on the table name and columns used in the SELECT statement. For example, if you specify column names in uppercase, the XML attributes will be in uppercase. You may need to keep this in mind while parsing the XML data in your application. By default, the AUTO mode returns all the column values as XML attributes. If you want, you can return them as elements instead. This is achieved by using the ELEMENTS clause with the AUTO mode. Listing 11-2 shows how the ELEMENTS clause works.

Listing 11-2. Using the ELEMENTS Clause of the AUTO Mode

```
SELECT EmployeeID,FirstName,LastName FROM Employees FOR XML AUTO,ELEMENTS
```

```
<EMPLOYEES>
<EMPLOYEEID>1</EMPLOYEEID>
<FIRSTNAME>Nancy</FIRSTNAME>
<LASTNAME>Davolio</LASTNAME>
</EMPLOYEES>
....
```

As you can see, we specify the ELEMENTS clause after the AUTO mode. Notice how the column values are returned as elements this time. The names of the elements are the same as the column names.

Note The XML data returned by the FOR XML clause in the preceding code is not well formed by default. It doesn't include the root element. However, as you will see later, you can specify the root element yourself.

The RAW Mode

The RAW mode of the FOR XML clause returns the XML data as zero or more XML elements. By default, the name of the elements is <row>. You can change this default behavior by specifying an element name yourself. The column values are returned as XML attributes. Listing 11-3 shows the use of RAW mode.

Listing 11-3. Using the RAW Mode of the FOR XML Clause

```
SELECT EmployeeID,FirstName,LastName FROM Employees FOR XML RAW
```

```
<row EmployeeID="1" FirstName="Nancy" LastName="Davolio"/>
<row EmployeeID="2" FirstName="Andrew" LastName="Fuller"/>
<row EmployeeID="3" FirstName="Janet" LastName="Leverling"/>
<row EmployeeID="4" FirstName="Margaret" LastName="Peacock"/>
....
```

As you can see, the FOR XML clause is followed by the RAW mode. The returned XML contains <row> elements with attributes holding the column values. If you want to change the default element name, you can specify your own element name, as shown in Listing 11-4.

Listing 11-4. Assigning a Custom Element Name to the Output of RAW Mode

```
SELECT EmployeeID,FirstName,LastName FROM Employees FOR XML RAW ('Employee')
```

```
<Employee EmployeeID="1" FirstName="Nancy" LastName="Davolio"/>
<Employee EmployeeID="2" FirstName="Andrew" LastName="Fuller"/>
<Employee EmployeeID="3" FirstName="Janet" LastName="Leverling"/>
<Employee EmployeeID="4" FirstName="Margaret" LastName="Peacock"/>
....
```

As you can see, we've now specified Employee as the element name in parentheses. This element name is given to all the returned rows.

Returning the Schema of the XML

The XMLSHEMA clause of the FOR XML clause allows you to return the XSD Schema of the XML data being returned. You may use this schema to validate your data further in your application. Listing 11-5 shows how the XMLSHEMA clause is used.

Listing 11-5. Returning an XML Schema

```
SELECT EmployeeID,FirstName,LastName FROM Employees FOR XML AUTO, XMLSHEMA
```

```
<xsd:schema targetNamespace="urn:schemas-microsoft-com:sql:SqlRowSet1"
xmlns:schema="urn:schemas-microsoft-com:sql:SqlRowSet1"
xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:sqltypes="http://schemas.microsoft.com/sqlserver/2004/sqltypes"
elementFormDefault="qualified">
<xsd:import namespace="http://schemas.microsoft.com/sqlserver/2004/sqltypes"
schemaLocation="http://schemas.microsoft.com/sqlserver/2004/sqltypes/sqltypes.xsd"/>
<xsd:element name="Employees">
<xsd:complexType>
<xsd:attribute name="EmployeeID" type="sqltypes:int" use="required"/>
<xsd:attribute name="FirstName" use="required">
<xsd:simpleType><xsd:restriction base="sqltypes:nvarchar" sqltypes:localeId="1033"
sqltypes:sqlCompareOptions="IgnoreCase IgnoreKanaType IgnoreWidth"
sqltypes:sqlSortId="52">
<xsd:maxLength value="10"/>
</xsd:restriction>
</xsd:simpleType>
</xsd:attribute>
<xsd:attribute name="LastName" use="required">
<xsd:simpleType>
<xsd:restriction base="sqltypes:nvarchar" sqltypes:localeId="1033"
sqltypes:sqlCompareOptions="IgnoreCase IgnoreKanaType IgnoreWidth"
sqltypes:sqlSortId="52">
<xsd:maxLength value="20"/>
</xsd:restriction>
</xsd:simpleType>
</xsd:attribute>
```

```

</xsd:complexType>
</xsd:element>
</xsd:schema>
<Employees xmlns="urn:schemas-microsoft-com:sql:SqlRowSet1" EmployeeID="1"
FirstName="Nancy" LastName="Davolio"/>
<Employees xmlns="urn:schemas-microsoft-com:sql:SqlRowSet1" EmployeeID="2"
FirstName="Andrew" LastName="Fuller"/>
....
```

As you can see, the XMLSCHEMA clause returns the XML Schema along with the data.

The PATH Mode

Though the AUTO and RAW modes return data in XML format, you have very little control over the nesting and naming conventions of the returned data. The PATH mode, on the other hand, allows you to specify the nesting structure as well as element and attribute names by using simple XPath syntax. Suppose you want to retrieve records from the Employees table in the format shown in Listing 11-6.

Listing 11-6. Custom Nesting and Naming

```

<Employee ID="1">
<Name>
<FirstName>Nancy</FirstName>
<LastName>Davolio</LastName>
</Name>
</Employee>
```

Each record is to be returned as an `<Employee>` element. The `EmployeeID` column value is to be returned as the `ID` attribute of the `<Employee>` element. There should be an element named `<Name>` with two sub-elements: `<FirstName>` and `<LastName>`. The `<FirstName>` and `<LastName>` elements should contain data from the `FirstName` and `LastName` columns, respectively. To retrieve XML data in this format, you can use the PATH mode, as shown in Listing 11-7.

Listing 11-7. Using the PATH Mode of the FOR XML Clause

```
SELECT EmployeeID "@ID", FirstName "Name/FirstName", LastName "Name/LastName"
FROM Employees FOR XML PATH ('Employee')
```

As you can see, the SELECT query now specifies certain extra pieces of information along with the column names. We want to return the `EmployeeID` column value as the `ID` attribute and hence the query adds `@ID` after the `EmployeeID` column. Similarly, the `FirstName` and the `LastName` columns are followed by the desired nesting and element names, that is, `Name/FirstName` and `Name/LastName`, respectively. The name of the element generated is specified after the PATH mode in parentheses. Notice how the XPath syntax `(@, /)` is used to specify the attributes and element nesting.

The EXPLICIT Mode

The EXPLICIT mode is possibly the most confusing mode of the FOR XML clause. On the one hand, it increases the complexity of the SELECT statement, but on the other, it gives much more fine-grained control on the resultant output.

Note I discuss the EXPLICIT mode only to the extent of giving a feeling of how it renders the XML output. In no way does this book try to teach you the EXPLICIT mode apart from the basics. If you want to learn about the EXPLICIT mode in detail, you may consider reading the official product documentation.

Suppose that you want to return the XML content as shown in Listing 11-8.

Listing 11-8. Customized XML Output Using EXPLICIT Mode

```
<Employee EmpID="1">
<FirstName>Nancy</FirstName>
<LastName>Davolio</LastName>
</Employee>
```

You can identify two levels in this markup. Level 1 consists of the `<Employee>` element, and level 2 consists of the `<FirstName>` and `<LastName>` elements. The `EmployeeID` column is outputted as the `EmpID` attribute of the `<Employee>` element and hence belongs to level 1.

When using EXPLICIT mode to generate this XML output, we need to write two SELECT queries:

- The first query will outline the structure, nesting, and element names of the various columns involved.
- The second query will actually fetch the data. The results of the two queries will be merged with a UNION clause.

Let's look at the first SELECT query (see Listing 11-9).

Listing 11-9. Defining the Structure of the XML Output

```
SELECT
1 AS Tag,
NULL AS Parent,
EmployeeID AS [Employee!1!EmpID],
FirstName AS [Employee!1!FirstName!element],
LastName AS [Employee!1!LastName!element]
FROM Employees
```

The query selects five columns: 1, NULL, `EmployeeID`, `FirstName`, and `LastName`. The last three columns are obvious, but what are 1 and NULL? The Tag and Parent columns are implicit columns in the resultant table that are created by SQL Server internally:

- The Tag column specifies the nesting level of the current element. A Tag value of 1 indicates that this query is defining the structure for level 1 of the XML output.
- The Parent column specifies the parent level of the current tag. A Parent value of NULL indicates that this is the top-level element.

Each column specified after the Parent column has some metadata specifications enclosed in square brackets. Multiple pieces of metadata are separated by an exclamation character (!):

- The first part indicates the name of the parent element of the current element or attribute.
- The second part indicates the tag number of the element.

- The third part indicates the name of the current element or attribute.
- If you specify only these three parts, the column value will be outputted as an attribute. To specify that it should be outputted as an element, you must specify the fourth part. The fourth part is a predefined keyword called `element`.

In our example, the top-level element is `<Employee>`. This top-level element name is decided by the first real column in the SELECT list (in our case, `EmployeeID`). The top-level element name is picked up from the first piece of metadata information specified after the `EmployeeID` column. We want to output the `EmployeeID` column value as an attribute named `EmpID`. Thus the parent level of the `EmpID` attribute is tag 1. Finally, the third piece of metadata information specifies that the attribute name is `EmpID`.

The metadata for the `FirstName` and `LastName` columns specifies that their parent is the level 1 element and they are to be outputted as `<FirstName>` and `<LastName>` elements, respectively.

The second SELECT query is shown in Listing 11-10.

Listing 11-10. Fetching the Data for the Structure Defined in the Previous Query

```
SELECT
1,
NULL,
EmployeeID,
FirstName,
LastName
FROM Employees
ORDER BY
[Employee!1!EmpID],
[Employee!1!FirstName!element],
[Employee!1!LastName!element]
FOR XML EXPLICIT
```

The query selects data for tag 1 and selects the `EmployeeID`, `FirstName`, and `LastName` columns. The `ORDER BY` clause indicates the sequence in which the elements will appear in the resultant XML. Finally, the query adds a `FOR XML EXPLICIT` clause.

Now that you understand both queries, you can use the `UNION ALL` clause, as shown in Listing 11-11.

Listing 11-11. Using the UNION ALL Clause

```
SELECT
1 AS Tag,
NULL AS Parent,
EmployeeID AS [Employee!1!EmpID],
FirstName AS [Employee!1!FirstName!element],
LastName AS [Employee!1!LastName!element]
FROM Employees
UNION ALL
SELECT
1,NULL,
EmployeeID,
FirstName,
LastName
FROM Employees
ORDER BY [Employee!1!EmpID],
```

```
[Employee!1!FirstName!element],
[Employee!1!LastName!element]
FOR XML EXPLICIT
```

The UNION ALL clause combines the results of both of these queries, and you get the XML output shown in Listing 11-8. Let's go a bit further and assume that you want to retrieve XML in the format shown in Listing 11-12.

Listing 11-12. XML Output with Deeper Nesting

```
<Employee empid="1">
<Name>
<FName>Nancy</FName>
<LName>Davolio</LName>
</Name>
</Employee>
```

The XML output has one more level of nesting. The <FName> and <LName> elements are enclosed in the <Name> element, which in turn is enclosed in the <Employee> element. The EmployeeID column is outputted as an empid attribute. The SELECT queries required to generate this output are given in Listing 11-13.

Listing 11-13. SELECT Queries for Generating Output as Shown in Listing 11-12

```
SELECT
1 AS Tag,
NULL AS Parent,
EmployeeID AS [employee!1!empid],
FirstName AS [Name!2!FName!element],
LastName AS [Name!2!LName!element]
FROM Employees
```

UNION ALL

```
SELECT 2 AS Tag,
1 AS Parent,
EmployeeID,
FirstName,
LastName
FROM Employees
ORDER BY
[Employee!1!empid],
[Name!2!FName!element],
[Name!2!LName!element]
FOR XML EXPLICIT
```

The first SELECT statement defines the structure of the resultant XML output. Notice that this time, the FirstName and LastName columns define their parent element as <Name> and have a tag level of 2. They also define element names for the FirstName and LastName columns as <FName> and <LName>, respectively. The second query defines tag 2. It specifies that the parent of tag 2 is tag 1 via the Parent column. It orders the result set by using the ORDER BY clause as before. If you run this script in Management Studio, you should see the XML output shown in Listing 11-12.

Specifying the Root Element Name

In all the preceding queries, you obtained XML markup for an individual table row, but there was no root element specified for the markup. If you want, you can specify the root element by adding the ROOT clause, as shown in Listing 11-14.

Listing 11-14. Using the ROOT Clause

```
SELECT EmployeeID,FirstName,LastName FROM Employees FOR XML AUTO, ROOT('MyRoot')
```

```
<MyRoot>
<Employees EmployeeID="1" FirstName="Nancy" LastName="Davolio"/>
<Employees EmployeeID="2" FirstName="Andrew" LastName="Fuller"/>
...
</MyRoot>
```

As you can see, the ROOT clause is appended at the end of the query with the name of the root element in parentheses. The returned XML is now wrapped inside this root element.

Using OPENXML

As you've seen, the FOR XML clause of SQL Server allows you to retrieve relational data in XML format. However, there is another way to do it—the OPENXML function, which allows you to read XML data in a relational fashion. Suppose that you have XML markup that contains a list of employees, and your aim is to import this list into your Employees table. In the absence of something like OPENXML, accomplishing this task would be tedious. As you will soon see, the OPENXML function makes your job much easier. Listing 11-15 shows the source XML markup containing the employee listing.

Listing 11-15. The Source XML Markup

```
<Employees>
<Employee EmployeeID="10" FirstName="John" LastName="Moore" />
<Employee EmployeeID="11" FirstName="Bill" LastName="Short" />
</Employees>
```

As you can see, the root element of the markup is `<Employees>`. Further, it contains `<Employee>` elements representing employee records. The `EmployeeID`, `FirstName`, and `LastName` appear as attributes of the `<Employee>` element. To read any XML markup by using the OPENXML function, you need to perform the following steps:

1. Prepare and load the XML document for processing.
2. Call the OPENXML function as per your need.
3. Remove the loaded XML document from memory.

These three steps are illustrated in Listing 11-16.

Listing 11-16. Using the OPENXML Function

```

SET IDENTITY_INSERT Employees ON
DECLARE @hDoc INT
DECLARE @xml VARCHAR(1000)

SET @xml=
'<Employees>
<Employee EmployeeID="10" FirstName="John" LastName="Gates" />
<Employee EmployeeID="11" FirstName="Bill" LastName="Short" />
</Employees>'

EXEC sp_xml:preparedocument @hDoc OUTPUT, @xml

INSERT INTO EMPLOYEES (EMPLOYEEID,FIRSTNAME,LASTNAME)
(
SELECT * FROM
OPENXML(@hDoc,'Employees/Employee',0)
WITH (EmployeeID int,FirstName varchar(50),LastName varchar(50))
)

EXEC sp_xml:removedocument @hDoc

```

The script in Listing 11-16 declares two variables named hDoc and xml. The integer variable hDoc is used later for storing a handle to the loaded XML document. The VARCHAR variable xml is used to store the XML markup shown in Listing 11-15 as a string. The SET statement assigns the XML markup to the xml variable. Then we call the sp_xml:preparedocument system stored procedure, which parses and loads the supplied XML markup in memory. It returns a handle to the loaded document in the form of an integer.

Next, this handle is collected in the hDoc variable that we declared earlier. Then an INSERT statement is executed, making use of the OPENXML function. Observe the call to OPENXML carefully. The OPENXML function is used in a SELECT statement as if it were a table. It accepts three parameters:

- The first parameter is a handle to the XML data loaded by using sp_xml:preparedocument.
- The second parameter is an XPath pattern pointing to the node of the XML data that is to be treated as a row. In our example, this base path is Employees/Employee.
- The third parameter is a flag indicating the mapping between the XML data and the relational rowset. The third parameter can take the values shown in Table 11-2.

Table 11-2. Mapping Between XML Data and a Relational Rowset

Flag Value	Description
0	Specifies that attributes of the XML elements are supplying column values for the relational rowset. This is the default.
1	Specifies that attributes of the XML elements are supplying column values for the relational rowset. When combined with a flag value of 2, attributes are picked up as column values and then element values are assigned to the remaining columns.
2	Specifies that elements of the source XML are supplying column values for the relational rowset.
8	This flag can be combined with 1 or 2 and indicates that the consumed data should not be copied to the overflow property @mp:xmltext.

Further, the WITH clause of OPENXML specifies the structure of the resultant rowset. The structure can be specified as a comma-separated list of column names and their data types. In our example, we have three columns: EmployeeID, FirstName, and LastName. Note that these column names are the same as the attribute names in the source XML markup.

Thus the rowset returned from the SELECT statement and OPENXML is fed to the INSERT statement. The INSERT statement then adds the data to the Employees table. In our example, it will add two rows.

After the INSERT operation is done, the XML document is removed from memory by using another system stored procedure: sp_xml_removedocument. This accepts the handle of an XML document loaded previously by using sp_xml_preparedocument and cleans up the memory consumed by the document. Calling sp_xml_removedocument is very important because failing to do so can waste valuable memory of your application.

Note A thorough discussion of the OPENXML clause is outside the scope of this book. The aim here is to give you a basic understanding of the XML functionality of SQL Server.

Using SQLXML Features

SQLXML provides you with a set of managed classes, which you can use in your .NET applications to query the SQL Server database and read the returned results in XML format. You can also send updates from the client application in special XML formats, and SQL Server can update the database.

Note Make sure to download and install SQLXML 4.0 SP1 before you continue with the remaining examples of this chapter.

The SQLXML Managed Classes

SQLXML provides you with a set of managed classes that can be used to execute queries against the database and return results in XML form. The classes provided by SQLXML physically reside in an assembly, called Microsoft.Data.SqlXml. The three core classes exposed by SQLXML are listed in Table 11-3.

Table 11-3. SQLXML Managed Classes

Class Name	Description
SqlXmlCommand	Allows you to execute queries as well as nonqueries against the database. This class exposes methods such as ExecuteNonQuery(), ExecuteStream(), and ExecuteXmlReader(). This class is analogous to the ADO.NET SqlCommand class.
SqlXmlParameter	Represents parameters to the queries executed by using the SqlXmlCommand class. This class is analogous to the ADO.NET SqlParameter class.
SqlXmlAdapter	Used to interact with the ADO.NET DataSet class. This class is analogous to the ADO.NET SqlDataAdapter class.

All the preceding classes can use the SQL Server OLEDB (SQLOLEDB) provider or the SQL Native Client to communicate with the underlying database. In the next few sections, you learn how the SQLXML classes can be used in your .NET applications.

Executing SELECT Queries

Let's begin by developing an application that will allow you to execute SELECT queries against the SQL Server database. The application user interface is shown in Figure 11-2.

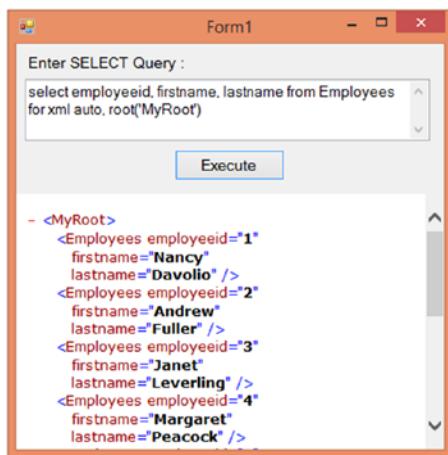


Figure 11-2. Application for executing SELECT queries via SqlXmlCommand

The application consists of a text box for entering SELECT queries. Note that these SELECT queries must use some mode of the FOR XML clause you learned earlier. The Execute button executes the query and displays the results in a Web Browser control. The Click event handler of the Execute button is shown in Listing 11-17.

Listing 11-17. Using the SqlXmlCommand Class

```
private void button1_Click(object sender, EventArgs e)
{
    string strConn =
        @"Provider=SQLOLEDB;server=.\sqlexpress;database=northwind;integrated security=SSPI";
    SqlXmlCommand cmd = new SqlXmlCommand(strConn);
    cmd.CommandText = textBox1.Text;
    Stream stream= cmd.ExecuteStream();
    StreamReader reader=new StreamReader(stream);
    StreamWriter writer =
        File.CreateText($"{Application.StartupPath}\\sqlxmlresults.xml");
    writer.Write(reader.ReadToEnd());
    writer.Close();
    webBrowser1.Navigate($"{Application.StartupPath}\\sqlxmlresults.xml");
}
```

Note Make sure to change the database connection string to match your development environment before running the preceding code.

The code declares a string variable for storing the database connection string. Notice the `Provider` parameter of the connection string, which specifies the SQLOLEDB provider. Then the code creates an instance of the `SqlXmlCommand` class by passing the connection string in its constructor. The `CommandText` property of `SqlXmlCommand` is set to the `SELECT` query entered in the text box, and the query is executed by calling the `ExecuteStream()` method of the `SqlXmlCommand` class.

The `ExecuteStream()` method executes your query and returns a `Stream` object containing the XML results. This `Stream` can then be used further to read the data. In the preceding code, the `Stream` is fed to a `StreamReader` class. We could have read the `Stream` byte by byte, but the `StreamReader` class makes our job easy.

The `CreateText()` method of the `File` class creates a new XML file at the specified location and returns a `StreamWriter` pointing to it. The XML returned from the database is read by using the `ReadToEnd()` method of the `StreamReader` class and is then written to the XML file. Finally, the `Navigate()` method of the Web Browser control is called to show the user the XML file.

There is an alternative way to do the same task. Have a look at Listing 11-18.

Listing 11-18. Using the ExecuteToStream() Method

```
private void button1_Click(object sender, EventArgs e)
{
    string strConn =
        @"Provider=SQLOLEDB;server=.\sqlexpress;database=northwind;integrated security=SSPI";
    SqlXmlCommand cmd = new SqlXmlCommand(strConn);
    cmd.CommandText = textBox1.Text;
    StreamWriter writer =
        File.CreateText($"{Application.StartupPath}\\sqlxmlresults.xml");
    cmd.ExecuteToStream(writer.BaseStream);
    writer.Close();
    webBrowser1.Navigate($"{Application.StartupPath}\\sqlxmlresults.xml");
}
```

The code in Listing 11-18 looks very similar to that in Listing 11-17. The difference is that it calls the `ExecuteToStream()` method instead of `ExecuteStream()`, and by doing so emits the XML output to an existing Stream. The `BaseStream` property of the `StreamWriter` class returns the underlying Stream, which is then supplied to the `ExecuteToStream()` method.

Note You can also use the `ExecuteXmlReader()` method of the `SqlXmlCommand` class. This method is identical to the `ExecuteXmlReader()` method of the `SqlCommand` class that you learned about in Chapter 7.

Executing Parameterized SELECT Queries

It is quite common for your SELECT queries to have some parameters, and the technique to execute parameterized queries is similar to ADO.NET. However, there are a few differences. First, a parameter is represented by the `SqlXmlParameter` class. Second, the `SqlXmlCommand` class doesn't have a `Parameters` collection as does the `SqlCommand` class, so you need to call the `CreateParameter()` method of the `SqlXmlCommand` class to create a new parameter that belongs to the command. The value of the parameter can then be set. To illustrate the use of the `SqlXmlParameter` class, we will create an application like the one shown in Figure 11-3.



Figure 11-3. Application for executing parameterized queries

The application allows you to fetch details of only one employee whose `EmployeeID` is specified in the text box. The returned XML data is displayed in the Web Browser control as before. Listing 11-19 shows the Click event handler of the Execute button.

Listing 11-19. Using the `SqlXmlParameter` Class

```

private void button1_Click(object sender, EventArgs e)
{
    string strConn =
        @"Provider=SQLOLEDB;server=.\sqlexpress;database=northwind;integrated security=SSPI";
    string sql = "SELECT employeeid,firstname,lastname FROM employees
                 WHERE employeeid=? FOR XML AUTO,ROOT('MyRoot')";
    SqlXmlCommand cmd = new SqlXmlCommand(strConn);
    cmd.CommandText = sql;

```

```

SqlXmlParameter param = cmd.CreateParameter();
param.Value = textBox1.Text;
StreamWriter writer =
    File.CreateText($"{Application.StartupPath}\\sqlxmlresults.xml");
cmd.ExecuteToStream(writer.BaseStream);
writer.Close();
webBrowser1.Navigate($"{Application.StartupPath}\\sqlxmlresults.xml");
}

```

Examine the SELECT query carefully. It has a WHERE clause with a parameter marked with a question mark (?). Further, the CreateParameter() method is called on the SqlXmlCommand class. The CreateParameter() method creates and returns a new SqlXmlParameter. You can then set the Value property of this SqlXmlParameter class. If your query has more than one parameter, you will need to call the CreateParameter() method once for each parameter. Note that the sequence of parameters in the query and the sequence in which you create SqlXmlParameter objects must be the same. After creating the required parameter, the XML output is saved to a FileStream by using the ExecuteToStream() method of SqlXmlCommand.

Filling a DataSet

A DataSet is one of the most commonly used objects for data binding and disconnected processing. It is obvious that the SQLXML object model must provide some mechanism to populate DataSet objects, and the SqlXmlAdapter fits the bill. It allows you to populate a DataSet and reflect the changes made to the DataSet back in the database. To illustrate the use of SqlXmlAdapter in populating a DataSet, you need to create an application like the one shown in Figure 11-4.

	employeeid	firstname	lastname
*	1	Nancy	Davolio
	2	Andrew	Fuller
	3	Janet	Leverling
	4	Margaret	Peacock
	5	Steven	Buchanan
	6	Michael	Suyama
	7	Robert	King
	8	Laura	Callahan
	9	Anne	Dodsworth

Figure 11-4. Application that fills a DataSet by using SqlXmlAdapter

The application consists of a DataGridView control. When the form loads, a DataSet is filled with all the records from the Employees table and the resultant DataSet is bound to the DataGridView control. The Load event handler that does this job is shown in Listing 11-20.

Listing 11-20. Filling a DataSet with SqlXmlAdapter

```
private void Form1_Load(object sender, EventArgs e)
{
    string strConn =
        @"Provider=SQLOLEDB;server=.\sqlexpress;database=northwind;integrated security=SSPI";
    string sql = "SELECT employeeid,firstname,lastname FROM employees FOR XML AUTO";
    SqlCommand cmd = new SqlCommand(sql, strConn);
    cmd.CommandText = sql;
    DataSet ds = new DataSet();
    SqlXmlAdapter da = new SqlXmlAdapter(cmd);
    da.Fill(ds);
    dataGridView1.DataSource = ds.Tables[0].DefaultView;
}
```

The code creates a `SqlCommand` object as before. It then creates a new instance of the `DataSet` and `SqlXmlAdapter` classes. The `SqlXmlAdapter` accepts the `SqlCommand` object as a parameter and thus the `SELECT` query (or stored procedure) is passed to it. The `Fill()` method of `SqlXmlAdapter` is then called by passing a `DataSet` object as a parameter. The `Fill()` method populates the `DataSet` with the results returned from the query. Finally, the `DataSet` is bound to the `DataGridView` control.

Updating a DataSet by Using `SqlXmlAdapter`

In the preceding example, we simply populated a `DataSet` with the help of the `SqlXmlAdapter` class. What if you make changes to the `DataSet` data and want to save those changes in the database? The `SqlXmlAdapter` does provide the `Update()` method that updates the database with any changes to your `DataSet`. However, you need to do a bit more work than that. While filling the `DataSet`, you need to specify the XSD Schema for the `DataTable` being created. This schema provides mapping between the `DataTable` column names and the actual table column names. In our example, we retrieve three columns of the Employee table: `EmployeeID`, `FirstName`, and `LastName`. The schema for this data structure is shown in Listing 11-21.

Listing 11-21. Schema—Employees.xsd—for Our Data

```
<?xml version="1.0" encoding="utf-8" ?>
<xss:schema xmlns:xss="http://www.w3.org/2001/XMLSchema">
    <xss:element name="Employees">
        <xss:complexType>
            <xss:sequence>
                <xss:element name="EmployeeID" type="xs:integer"/>
                <xss:element name="FirstName" type="xs:string"/>
                <xss:element name="LastName" type="xs:string"/>
            </xss:sequence>
        </xss:complexType>
    </xss:element>
</xss:schema>
```

The schema defines a root element called `<Employees>`, which has three child elements: `<EmployeeID>`, `<FirstName>`, and `<LastName>`. Note that the schema defines the columns as elements and not as attributes. To see the `SqlXmlAdapter` class in action, you need to develop an application as shown in Figure 11-5.

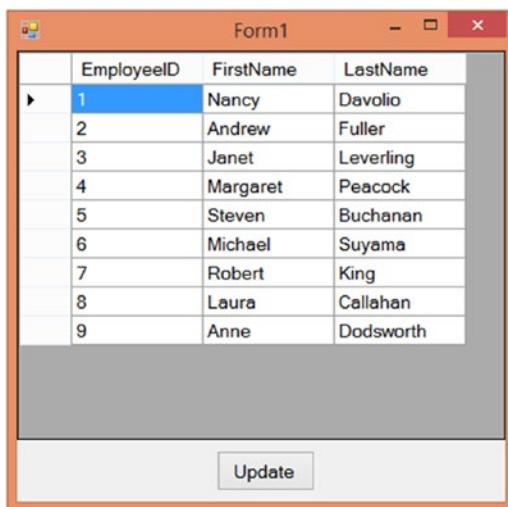


Figure 11-5. Application for illustrating the Update() method of SqlXmlAdapter

The application consists of a DataGridView control that displays all the employees from the Employees table. You can change the data in the DataGridView and click the Update button to save the changes back to the database. The complete code that makes this application work is shown in Listing 11-22.

Listing 11-22. Saving Changes Made to a DataSet

```
DataSet ds = new DataSet();
SqlXmlAdapter da;
SqlXmlCommand cmd;
string strConn =
    @"Provider=SQLOLEDB;server=.\sqlexpress;database=northwind;integrated security=SSPI";

private void Form1_Load(object sender, EventArgs e)
{
    cmd = new SqlXmlCommand(strConn);
    cmd.RootTag = "ROOT";
    cmd.CommandText = "Employees";
    cmd.CommandType = SqlXmlCommandType.XPath;
    cmd.SchemaPath = $"{Application.StartupPath}\\employees.xsd";
    ds = new DataSet();
    da = new SqlXmlAdapter(cmd);
    da.Fill(ds);
    dataGridView1.DataSource = ds.Tables[0].DefaultView;
}

private void button1_Click(object sender, EventArgs e)
{
    da.Update(ds);
}
```

The code in Listing 11-22 shows several interesting things. The `SqlXmlCommand`, `DataSet`, and `SqlXmlAdapter` variables are declared at the form level because we will be using them in more than one place. Notice the code marked in bold. It sets the `RootTag` property of the `SqlXmlCommand` property. The `AUTO` mode of the `FOR XML` clause doesn't return data along with a root element by default, so this property is used to indicate the name of the root element inside which the rest of the XML data will be wrapped.

The `CommandType` property is set to `XPath`, indicating that the `CommandText` property is an `XPath` expression. This means that this time the `CommandText` property is not a `SELECT` query, but is the `XPath` expression `Employees`, which will return various `<Employees>` elements.

The `CommandType` property of the `SqlXmlCommand` class is of type `SqlXmlCommandType`. The possible values of the `SqlXmlCommandType` enumeration are listed in Table 11-4.

Table 11-4. Values of the `SqlXmlCommandType` Enumeration

Value	Description
<code>DiffGram</code>	Indicates that <code>CommandText</code> is a <code>DiffGram</code>
<code>Sql</code>	Indicates that <code>CommandText</code> is a <code>SQL</code> statement (default)
<code>Template</code>	Indicates that <code>CommandText</code> is a template
<code>TemplateFile</code>	Indicates that <code>CommandText</code> is a template file
<code>UpdateGram</code>	Indicates that <code>CommandText</code> is an <code>UpdateGram</code>
<code>XPath</code>	Indicates that <code>CommandText</code> is a valid <code>XPath</code> expression

Further, the `SchemaPath` property specifies the path of the schema file that we created earlier. Then the `SqlXmlAdapter` populates a `DataSet`, which is bound to the `DataGridView`.

After the data is displayed in the `DataGridView`, you can modify it. After the modifications are complete, you need to click the `Update` button. The `Click` event of the `Update` button calls the `Update()` method of `SqlXmlAdapter`, which accepts the `DataSet` whose changes are to be reflected in the database. In Chapter 7, you learned that the `DataSet` class internally tracks the changes made to the data by using the `DiffGram` format. The same `DiffGram` is used by the `SqlXmlAdapter` class to propagate the changes back to the database.

Applying XSLT Templates

In Chapter 6, you learned to apply XSLT style sheets to XML data. You saw that XSLT allows you to transform XML data from one form to another. The same concept also can be applied in SQLXML, where you may want to apply XSLT templates to whatever data you receive in your client application. This is accomplished by using the `XslPath` property of the `SqlXmlCommand` class. To demonstrate the use of `XslPath`, you need to develop an application like the one shown in Figure 11-6.

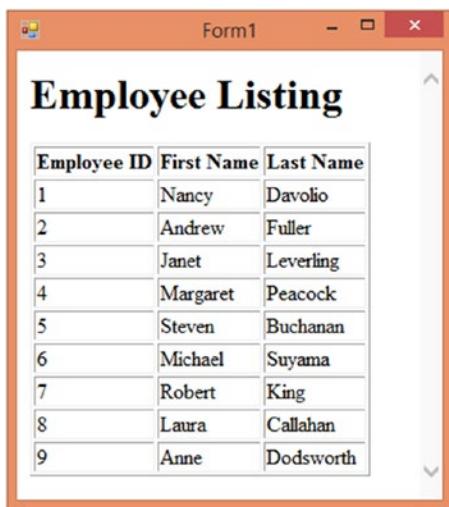


Figure 11-6. Application to illustrate the use of the XslPath property

The application consists of a Web Browser control. When the form loads, a SELECT query is executed by using `SqlXmlCommand`. An XSLT style sheet is then applied to the returned XML data to transform it into HTML. The resultant HTML document is then displayed in the Web Browser control.

Before you write any code, you must create an XSLT style sheet named `Employees.xslt` as shown in Listing 11-23.

Listing 11-23. Employees.xslt Markup

```
<?xml version="1.0" encoding="UTF-8" ?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
  <xsl:template match="/">
    <html>
      <body>
        <h1>Employee Listing</h1>
        <table border="1">
          <tr>
            <th>Employee ID</th>
            <th>First Name</th>
            <th>Last Name</th>
          </tr>
          <xsl:for-each select="root/employees">
            <tr>
              <td>
                <xsl:value-of select="@EmployeeID"/>
              </td>
              <td>
                <xsl:value-of select="@FirstName"/>
              </td>
```

```

<td>
    <xsl:value-of select="@LastName"/>
</td>
</tr>
</xsl:for-each>
</table>
</body>
</html>
</xsl:template>
</xsl:stylesheet>

```

The style sheet iterates through all the `<Employees>` elements and renders an HTML table. The HTML table displays the attribute values in various cells. Note that we will be using the AUTO mode of the FOR XML clause, which returns column values as XML attributes. That is why the style sheet uses attribute names (@EmployeeID, @FirstName, and @LastName). The code that actually executes the SELECT query and performs the transformation is shown in Listing 11-24.

Listing 11-24. Applying an XSLT Style Sheet

```

private void Form1_Load(object sender, EventArgs e)
{
    string strConn =
        @"Provider=SQLOLEDB;server=.\sqlexpress;database=northwind;integrated security=SSPI";
    SqlXmlCommand cmd = new SqlXmlCommand(strConn);
    cmd.CommandText = "SELECT EmployeeID, FirstName, LastName
FROM employees FOR XML AUTO";
    cmd.RootTag = "root";
    cmd.XslPath = $"{Application.StartupPath}\\employees.xslt";
    StreamWriter writer =
        File.CreateText($"{Application.StartupPath}\\sqlxmlresults.htm");
    cmd.ExecuteToStream(writer.BaseStream);
    writer.Close();
    webBrowser1.Navigate($"{Application.StartupPath}\\sqlxmlresults.htm");
}

```

Notice the code marked in bold. This time the SELECT statement doesn't contain a ROOT clause. We could indeed have used it, but the code achieves the same thing with the help of the RootTag property of the `SqlXmlCommand` class. Recollect that in the absence of a ROOT clause in the FOR XML query, the returned XML data doesn't contain a root element. The RootTag property of `SqlXmlCommand` specifies the name of the root tag inside which the output of the SELECT query will be wrapped.

The XSLT style sheet to be used for transformation is specified via the `XslPath` property of the `SqlXmlCommand` class. This way, the `SqlXmlCommand` class knows which style sheet to apply to the returned XML data. The rest of the code should be familiar to you, as we discussed it in previous examples. It simply saves the transformed XML data into a disk file and displays that file in the Web Browser control.

Writing Template Queries

In the preceding example, we specified the SELECT query directly in code. There is an alternative to this too: you can store the queries in an XML file and specify the path of this XML file as the CommandText of the SqlCommand class. These XML files are called *XML templates*. The structure of this XML file can be seen in Listing 11-25.

Listing 11-25. Creating an XML Template

```
<?xml version="1.0" encoding="utf-8" ?>
<ROOT xmlns:sql="urn:schemas-microsoft-com:xml-sql">
    <sql:header>
        <sql:param name='EmpID'>1</sql:param>
    </sql:header>
    <sql:query>
        SELECT EmployeeID,FirstName,LastName FROM Employees
        WHERE employeeid>@Empid FOR XML AUTO
    </sql:query>
</ROOT>
```

The root element <ROOT> is a user-defined element, but the namespace `urn:schemas-microsoft-com:xml-sql` is necessary. The <ROOT> element contains an optional section called <sql:header>, which is used to define parameters used by your query (if any). Each parameter is specified by using a <sql:param> element. The name attribute of the <sql:param> element indicates the name of the parameter, while the value of the parameter is stored within the <sql:param> and </sql:param> tags. The actual query is stored in the <sql:query> section. The query uses the parameter by prefixing its name with the @ symbol.

To use this XML template file, you need to create an application like the one shown in Figure 11-7.

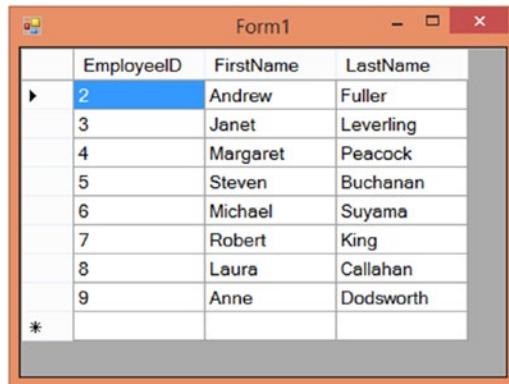


Figure 11-7. Application that illustrates the use of XML templates

The application consists of a DataGridView that displays all the records from the Employees table. The Load event of the form contains all the code necessary to use the XML template (see Listing 11-26).

Listing 11-26. Using XML Templates

```
private void Form1_Load(object sender, EventArgs e)
{
    string strConn =
        @"Provider=SQLOLEDB;server=.\sqlexpress;database=northwind;integrated =>
    security=SSPI";
    SqlXmlCommand cmd = new SqlXmlCommand(strConn);
    cmd.CommandType = SqlXmlCommandType.TemplateFile;
    cmd.CommandText = $"{Application.StartupPath}\\querytemplate.xml";
    DataSet ds = new DataSet();
    SqlXmlAdapter da = new SqlXmlAdapter(cmd);
    da.Fill(ds);
    dataGridView1.DataSource = ds.Tables[0].DefaultView;
}
```

Notice the code marked in bold. This time the `CommandType` property of the `SqlXmlCommand` class is set to `TemplateFile`. This indicates that the `CommandText` property will be specifying the path of the XML template file. Then the `CommandText` property is set to the path of the XML template file we just created in Listing 11-25. The instance of `SqlXmlAdapter` is used as before to populate a `DataSet`. The `DataSet` is finally bound to the `DataGridView` control.

Updating Data with DiffGrams

In Chapter 7, you learned that `DataSet` objects can be serialized as XML documents. While serializing a `DataSet` object, we used an `XmlWriteMode` enumeration to specify how the data is to be written. Now, one of the options of `XmlWriteMode` was `DiffGram`, which persisted the `DataSet` contents in `DiffGram` format. Imagine that you have such a `DiffGram` containing inserts, updates, and deletes and you want to save these changes back to the database. One way to do this is to use `DataSet` and `SqlXmlAdapter`, which you've already seen.

There is another technique that also involves the `SqlXmlCommand` class. The `SqlXmlCommand` class can come in handy if you have a raw `DiffGram` that is not necessarily loaded in a `DataSet`. To illustrate the use of the `SqlXmlCommand` class, you need to develop an application like the one shown in Figure 11-8.

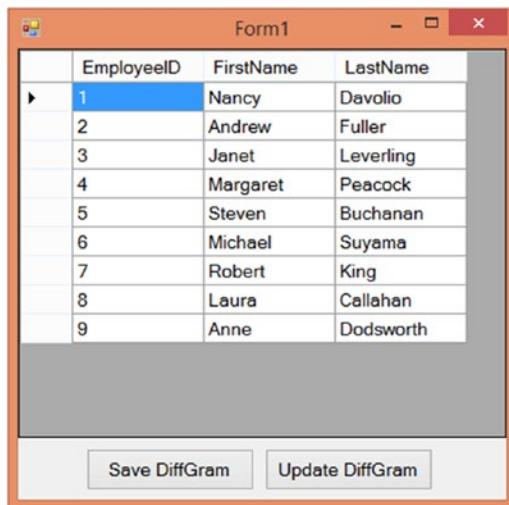


Figure 11-8. Application for updating DiffGrams

The application consists of a DataGridView control for displaying all the records from the Employees table. There are two buttons: Save DiffGram and Update DiffGram. The former saves the contents of the DataSet to a disk file in DiffGram format. The latter button reads the previously saved DiffGram and updates the database.

The Load event handler of the form contains the code shown in Listing 11-27.

Listing 11-27. Filling a DataSet

```
string strConn = @"Provider=SQLOLEDB;server=.; database=northwind;user id=sa;password=sa";
DataSet ds = new DataSet();

private void Form1_Load(object sender, EventArgs e)
{
    SqlCommand cmd = new SqlCommand(strConn);
    cmd.RootTag = "ROOT";
    cmd.CommandText = "Employees";
    cmd.CommandType = CommandType.XPath;
    cmd.SchemaPath = $"{Application.StartupPath}\\employees.xsd";
    SqlDataAdapter da = new SqlDataAdapter(cmd);
    da.Fill(ds);
    dataGridView1.DataSource = ds.Tables[0].DefaultView;
}
```

The code should be familiar to you, as you used it in previous examples. It simply populates a DataSet by using the SqlDataAdapter class. The DataSet acts as the DataSource for the DataGridView control. The code that saves this DataSet as a DiffGram goes in the Click event of the Save DiffGram button and is shown in Listing 11-28.

Listing 11-28. Saving a DataSet as a DiffGram

```
private void button2_Click(object sender, EventArgs e)
{
    StreamWriter writer=File.CreateText($"{Application.StartupPath}\\employees.xml");
    ds.WriteXml(writer, XmlWriteMode.DiffGram);
    writer.Close();
}
```

The code calls the WriteXml() method of DataSet to save its contents to an XML file (Employees.xml). The XmlWriteMode parameter of WriteXml() indicates that DiffGram format is to be used while writing the data. This DiffGram is executed against the database when you click the Update DiffGram button. The Click event handler of the Update DiffGram button is shown in Listing 11-29.

Listing 11-29. Updating a DiffGram in a Database

```
private void button1_Click(object sender, EventArgs e)
{
    StreamReader reader = File.OpenText($"{Application.StartupPath}\\employees.xml");
    SqlCommand cmd = new SqlCommand(strConn);
    cmd.CommandType = CommandType.DiffGram;
    cmd.CommandText = reader.ReadToEnd();
    cmd.SchemaPath = $"{Application.StartupPath}\\employees.xsd";
```

```

cmd.ExecuteNonQuery();
MessageBox.Show("DiffGram updated to database successfully!");
}

```

The code opens the Employees.xml file in a `StreamReader` object. It then creates an instance of the `SqlXmlCommand` class and sets the `CommandType` property of the `SqlXmlCommand` instance to `DiffGram`. This is how you tell `SqlXmlCommand` about your intention to update a `DiffGram`. When the `CommandType` is `DiffGram`, the `CommandText` property must contain the `DiffGram` itself. The `ReadToEnd()` method of `StreamReader` reads the complete `DiffGram` and assigns it to the `CommandText` property.

If you want to update the database by using the `DiffGram` method, you must specify the `SchemaPath` property also. In this case, the schema is the same as we created in Listing 11-21 earlier. Finally, the `ExecuteNonQuery()` method of the `SqlXmlCommand` is called to save all the changes to the database. The `ExecuteNonQuery()` method is used for executing queries that do not return anything. In our example, we simply wanted to update the `DiffGram` to the database and hence we used the `ExecuteNonQuery()` method.

Note Just like `DiffGram`, the `SqlXmlCommand` object also allows you to update `UpdateGrams`. The `UpdateGram` format is similar to `DiffGram` in that it keeps the differential versions of the data. However, the `DataSet` class doesn't have any methods to serialize itself in `UpdateGram` format. You can think of `DiffGram` as a subset of `UpdateGram`.

The XML Data Type

Up until now, you've seen various features of SQL Server that provide a strong integration between relational and XML data. But that's not all. This section gives the next installment of the XML features of SQL Server: the XML data type. Prior to SQL Server 2005, storing XML data in a table essentially meant that you had to use a `VARCHAR` or `TEXT` column for the data. From the point of view of storage, this was fine; but from a data-manipulation point of view, it was tedious. The XML data was treated just like any other text data. The new XML data type introduced in SQL Server 2005 is exclusively for storing XML documents and fragments.

Note An XML document is markup that contains the root element, whereas an XML fragment is markup without any root element. Remember that the `FOR XML` clause by default returns XML fragments and not documents.

As well as storing XML data, you can also execute XQuery operations and special XML data-manipulation statements on the data. The XML data can have an XSD Schema attached to it so that data validations can be performed. You can also index tables on the basis of an XML column.

Note XQuery is a W3C recommendation that deals with querying XML documents. You can think of XQuery as SQL for XML data. The XQuery syntax is based on XPath expression syntax.

To begin, let's see how to add a column of type `XML` to a SQL Server table.

Creating a Table with an XML Column

To see how a column of type XML can be added to a SQL Server table, you will create a new table in the Northwind database called XMLDocs. Figure 11-9 shows the XMLDocs table in design mode.

	Name	Data Type	Allow Nulls
	Id	int	<input type="checkbox"/>
	XmlData	xml	<input checked="" type="checkbox"/>

Figure 11-9. Creating a table with an XML column

The XMLDocs table consists of two columns: Id and XmlData. The former column is the primary and is marked as an identity column, and the latter is of type XML.

Inserting, Modifying, and Deleting XML Data

Inserting, modifying, or deleting XML data is similar to any other data type. However, there are some points to keep in mind. Listing 11-30 shows how to use INSERT and UPDATE statements against a column of type XML.

Listing 11-30. Inserting and Updating XML Columns

```
-- Here goes INSERT
INSERT INTO xmldocs(xmldata)
VALUES(
'<Employee EmployeeID="1">
<FirstName>Nancy</FirstName>
<LastName>Davolio</LastName>
</Employee>')

-- Here goes UPDATE
UPDATE xmldocs
SET xmldata='
<Employee EmployeeID="1">
<FirstName>Nancy</FirstName>
<LastName>Davolio</LastName>
</Employee>'
WHERE Id=1
```

As you can see, for an INSERT or an UPDATE against a column of the XML data type, you can use XML data in string format. You can also declare a variable of type XML in your Transact-SQL (T-SQL) scripts, as shown in Listing 11-31.

Listing 11-31. Declaring a Variable of Type XML

```
DECLARE @xmldata xml
SET @xmldata='
<Employee EmployeeID="2">
<FirstName>Nancy</FirstName>
```

```
<LastName> Davolio</LastName>
</Employee>'
```

```
UPDATE xmldocs
SET xmldata=@xmldata
WHERE Id=1
```

The script declares a variable called `xmldata` of type XML and stores some XML markup in it. The `xmldata` variable is then used in the UPDATE statement. If you want to explicitly convert a string value into the XML data type, you can use the `CONVERT` function as shown in Listing 11-32.

Listing 11-32. Converting String Values to an XML Data Type

```
DECLARE @xmldata VARCHAR(255)
SET @xmldata='
<Employee EmployeeID="2">
<FirstName>Nancy</FirstName>
<LastName> Davolio</LastName>
</Employee>'

UPDATE xmldocs
SET xmldata=CONVERT(xml,@xmldata,0)
WHERE Id=1
```

The first parameter to the `CONVERT` function is the target data type. The second parameter is the source data to be converted, and the third parameter is the style. The value of 0 indicates that insignificant whitespace will be discarded. You might be wondering—if XML data can be represented as a string, why would we want to use XML variables at all? The answer is, using the XML data type is recommended because the XML data type checks that the XML data is well formed.

Methods of the XML Data Type

The XML data type provides some methods to query XML columns or variables. Some of these methods are listed in Table 11-5.

Table 11-5. Methods of the XML Data Type

Method	Description
<code>query()</code>	Queries an XML column or variable based on some XQuery expression and returns the results of the query.
<code>value()</code>	Queries an XML column or variable and returns a scalar value of the SQL data type.
<code>exist()</code>	Tells you whether the given XQuery expression returns any results.
<code>modify()</code>	Modifies the content of an XML data type column or variable with the help of XML Data Modification Language, discussed later in this chapter.
<code>nodes()</code>	Returns XML data as relational data.

Some of these methods are discussed in the following sections.

Using the query() Method

The `query()` method is used to query XML data by using XQuery expressions. Listing 11-33 illustrates how this method is used.

Listing 11-33. Using the `query()` Method

```
SELECT xmldata.query('/Employee[@EmployeeID=2]') FROM xmldocs
```

```
<Employee EmployeeID="2">
<FirstName>Nancy</FirstName>
<LastName> Davolio</LastName>
</Employee>
```

The SELECT query uses the `query()` method on the `Xmldata` column. The `query()` method accepts a valid XQuery expression and returns the matching nodes. In our example, we fetch the `<Employee>` element whose `EmployeeID` attribute value is 1. As you can see, the XQuery syntax is based on XPath syntax.

Using the value() Method

The `value()` method accepts an XQuery expression and returns a scalar (single) value. Listing 11-34 shows the use of this method.

Listing 11-34. Using the `value()` Method

```
SELECT xmldata.value('/(Employee/@EmployeeID)[1]','int') FROM xmldocs WHERE id=1
```

```
-----  
1
```

The `value()` method accepts two parameters:

- The first parameter is an XQuery.
- The second parameter is the target SQL Server data type.

In this example, we are trying to select the `EmployeeID` attribute value of the first employee. Note that the expression `/Employee/@EmployeeID` returns multiple rows, and hence we specify the row index to access by using array notation. The `EmployeeID` scalar value is to be represented as an integer, and hence the second parameter is `int`. Note that the data type name must be enclosed in quotes.

Using the exist() Method

The `exist()` method checks whether there are any nodes matching the supplied XQuery expression. Listing 11-35 illustrates the use of the `exist()` method.

Listing 11-35. Using the `exist()` Method

```
SELECT xmldata.exist('/Employee[@EmployeeID=1]') FROM xmldocs
```

The `exist()` method returns 1 if the XQuery expression returns at least one node, 0 if the XQuery expression returns zero nodes, and NULL if the XML column is null.

XML Data Modification Language (XML DML)

As SQL provides data-manipulation statements for relational data, so the XML DML of SQL Server allows you to insert, replace, and delete data from an XML column. The XML DML statements are used along with the `modify()` method mentioned in Table 11-5. Listing 11-36 shows a script that inserts, replaces, and deletes XML data from the `XmlData` column of the `XMLDocs` table.

Listing 11-36. Inserting, Replacing, and Deleting Content from an XML Column

```
-- Here goes insert
UPDATE xmldocs
SET xmldata.modify
(
insert <Employee EmployeeID="3">
<FirstName>Janet</FirstName>
<LastName>Leverling</LastName>
</Employee> after (/Employee)[2]')
)

-- Here goes replace

UPDATE xmldocs
SET xmldata.modify
(
replace value of
(/Employee/@EmployeeID)[1] with "10")

-- Here goes delete

UPDATE xmldocs
SET xmldata.modify
(
delete (/Employee[@EmployeeID=3])
')
```

The first UPDATE query uses the `modify()` method of the XML column to specify an `insert` XML DML statement that inserts a new `<Employee>` node at the end of the existing markup. Observe this syntax carefully. The whole `insert` statement is enclosed within quotes and acts as a parameter to the `modify()` method. The first expression in the `insert` statement is the new XML markup to be inserted followed by the `after` clause. In our example, we want to insert the new `<Employee>` after the second `<Employee>` node and hence we specify `(/Employee)[2]`. You can also use the `before`, as `first`, and as `last` clauses.

The second UPDATE query uses the `modify()` method along with the `replace value of` XML DML statement. The `replace value of` statement takes two expressions:

- The first specifies the markup to be replaced. In our example, we want to replace the `EmployeeID` attribute of the first `<Employee>` node.
- The second expression is the new value to be replaced. In our example, we want to assign a value of 10 to the `EmployeeID` attribute.

Finally, the third UPDATE statement uses the `modify()` method along with the `delete` XML DML statement. The `delete` statement takes the expression on the basis of which the markup is to be deleted. In our example, we want to delete an employee with `EmployeeID` equal to 3.

XQuery Support in the XML Data Type

While working with the XML data type, you saw that it heavily uses XQuery expressions. The XQuery expressions are in turn based on XPath syntax. In Chapter 4, you were introduced to XPath functions. The XQuery specifications support almost all the functions that you learned earlier.

Summary

SQL Server provides strong integration with XML. This chapter introduced you to many of the XML features of SQL Server, which allows you to view relational data as XML. This is done with the help of the FOR XML clause of the SELECT statement. You can also look at XML data in a relational way by using the OPENXML function.

You also saw how SQL Server makes it easy to retrieve data in a client application with the help of the SQLXML managed classes. These classes allow you to select data as a stream, an `XmlReader`, or a `DataSet`. They also allow you to update UpdateGrams and DiffGrams in the database. The XML data type of SQL Server can be used to store whole XML documents or fragments and allows you to manipulate them via XML DML.

CHAPTER 12



XML in .NET Framework

Up until now, you have learned how to work with your own XML data. This includes reading, writing, validating, serializing, and querying XML data. Microsoft has used XML extensively in the .NET Framework. This use of XML comes in different flavors, such as XAML markup of note, server control markup of ASP.NET, and configuration system of the .NET Framework. Understanding the use of XML in the .NET Framework is therefore essential for any .NET developer. This chapter introduces you to many of these features. Specifically, you learn about the following topics:

- Using XAML in defining the WPF user interfaces
- Using ASP.NET server controls to define the web user interface
- Understanding ASP.NET server controls such as the XML, XML data source, TreeView, Menu, and SiteMap
- Using the configuration system of the .NET Framework
- Understanding the XML documentation

Note that although this chapter covers a broad range of topics, by no means does it give an exhaustive treatment to these topics. The focus here is to briefly point at the use of XML in various areas of the .NET Framework.

Using XAML to Define the WPF User Interface

You have been developing Windows Forms applications throughout this book. As you are aware, a Windows Forms are classes that contain all the code required to display the form and the event handlers. Thus two concerns—user interface and functioning (event handlers)—are mixed together. A better programming approach would be to separate these two concerns into their own units.

Windows Presentation Foundation (WPF) applications do just that. WPF uses a special vocabulary of XML called XAML (Extensible Application Markup Language) to define a user interface. The XAML markup typically resides in files with an .xaml extension. The code responsible for the functioning of the application (runtime logic such as event handlers and methods) is housed in a C# class. When you design a user interface of a Windows Forms application, the UI is translated into C# code. That's not the case with WPF applications. When you design a WPF user interface in Visual Studio, the UI is translated into XAML markup (and not into C# code).

The XAML markup is an XML markup and hence follows all the rules of XML grammar. You can create/edit an XAML markup in any XML/text editor, but Visual Studio provides a rich editor to work with it.

Just to understand how the XAML markup looks, you will create a WPF application as shown in Figure 12-1.

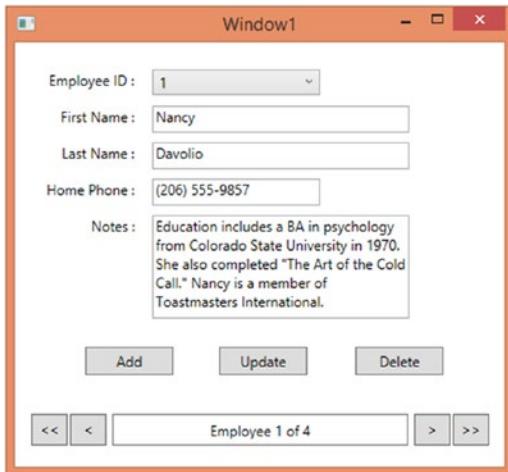


Figure 12-1. A WPF application for managing Employees.xml

This application should sound familiar to you because you developed a similar Windows Forms application in Chapter 2. As far as the functionality of the application is concerned, it's exactly same—add, update, and delete employees from the Employees.xml file. We are not going to discuss the functionality again to save some space. Our primary interest here is the XAML markup. You can grab the complete source code of this application from this book's source code download.

To develop this application, create a new WPF application project using Visual Studio (see Figure 12-2).

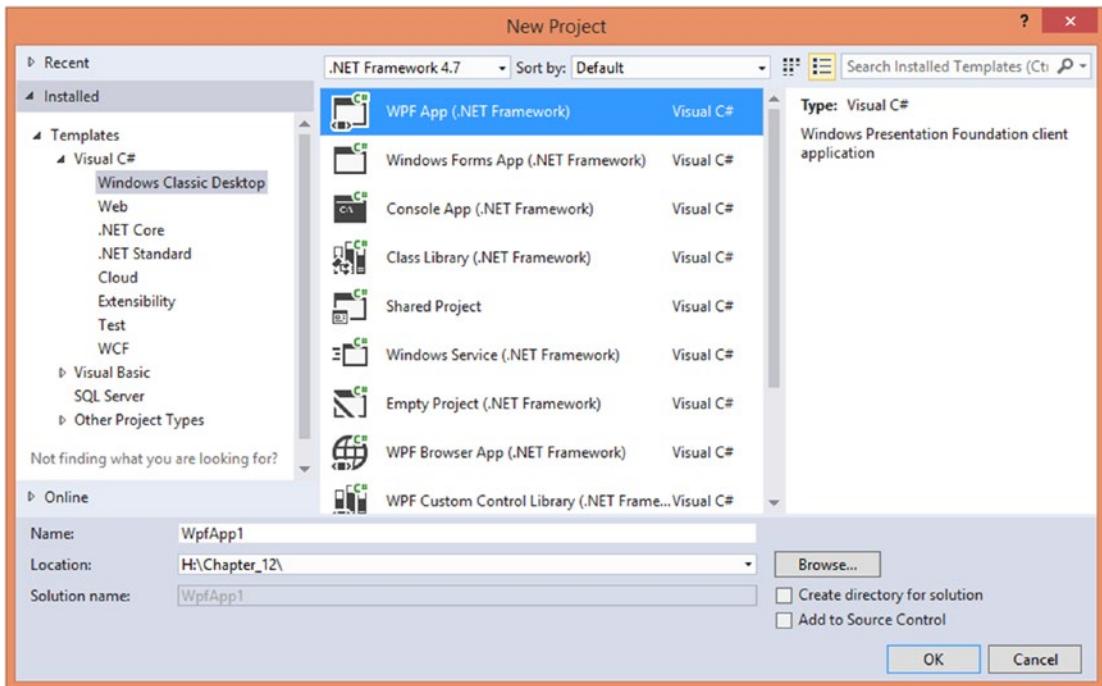


Figure 12-2. Creating a new WPF application project

Once the project is created, you will notice two .xaml files in it called App.xaml and MainWindow.xaml. Our interest is the MainWindow.xaml file, since it defines the user interface of our application. You can add WPF windows using the Add New Item dialog.

You can open the MainWindow.xaml file in the Visual Studio Designer (see Figure 12-3) and edit it in two ways:

- Drag and drop WPF controls from the toolbox onto the design surface and set their properties. Doing so will generate certain XAML markup for you.
- Manually edit the .xaml file and add the markup (primarily consisting of certain elements and their attributes) into it directly. The design surface will also reflect the relevant changes.

The MainWindow.xaml file ready for editing is shown in Figure 12-3. Figure 12-4 shows the toolbox with WPF controls.

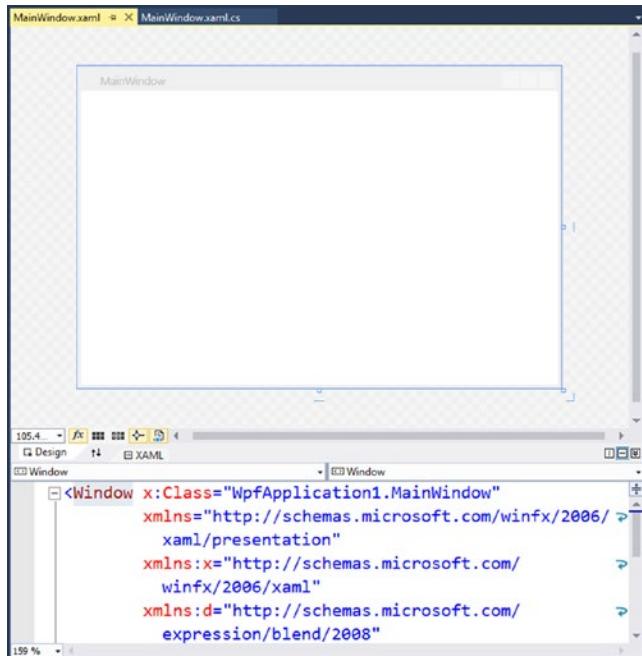


Figure 12-3. MainWindow.xaml in the Visual Studio Designer

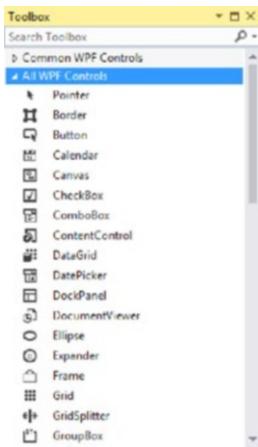


Figure 12-4. Toolbox showing WPF controls

You can try playing with the designer just to get some familiarity. And try to design a user interface of the application as shown earlier. We won't go into the details of the UI designing process here. The XAML markup responsible for the user interface is shown in Listing 12-1 (to save some space, some of the markup has been omitted from the listing).

Listing 12-1. XAML Markup Responsible for the User Interface

```

<Window x:Class="WpfAndXaml.MainWindow"
        xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
        xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
        xmlns:d="http://schemas.microsoft.com/expression/blend/2008"
        xmlns:mc="http://schemas.openxmlformats.org/markup-compatibility/2006"
        xmlns:local="clr-namespace:WpfAndXaml"
        mc:Ignorable="d"
        Title="Window1" Height="400.2" Width="433.431" Loaded="Window_Loaded">
    ...
    <Grid HorizontalAlignment="Center" Height="367" VerticalAlignment="Center"
          Width="396" Margin="10,10,9,10">
        <Label Content="Employee ID :" HorizontalAlignment="Left" Margin="13,22,0,0"
              VerticalAlignment="Top" RenderTransformOrigin="-0.575,0.017"/>
        <Label Content="First Name :" HorizontalAlignment="Left" Margin="23,53,0,0"
              VerticalAlignment="Top" RenderTransformOrigin="-0.575,0.017"/>
        <Label Content="Last Name :" HorizontalAlignment="Left" Margin="24,84,0,0"
              VerticalAlignment="Top" RenderTransformOrigin="-0.575,0.017"/>
        <Label Content="Home Phone :" HorizontalAlignment="Left" Margin="11,115,0,0"
              VerticalAlignment="Top" RenderTransformOrigin="-0.575,0.017"/>
        <Label Content="Notes :" HorizontalAlignment="Left" Margin="49,146,0,0"
              VerticalAlignment="Top" RenderTransformOrigin="-0.575,0.017"/>
        <ComboBox x:Name="comboBox1" HorizontalAlignment="Left" Margin="106,26,0,0"
                  VerticalAlignment="Top" Width="143"/>
        <TextBox x:Name="textBox1" HorizontalAlignment="Left" Height="23"
                  Margin="106,57,0,0" TextWrapping="Wrap" Text="TextBox" VerticalAlignment="Top"
                  Width="219" RenderTransformOrigin="0.439,-0.159"/>
    
```

```

<TextBox x:Name="textBox2" HorizontalAlignment="Left" Height="23"
TextWrapping="Wrap" Text="TextBox" VerticalAlignment="Top" Width="219"
Margin="106,88,0,0"/>
<TextBox x:Name="textBox3" HorizontalAlignment="Left" Height="23"
TextWrapping="Wrap" Text="TextBox" VerticalAlignment="Top" Width="143"
Margin="106,119,0,0"/>
<TextBox x:Name="textBox4" HorizontalAlignment="Left" Height="88"
TextWrapping="Wrap" Text="TextBox" VerticalAlignment="Top" Width="219"
Margin="106,150,0,0"/>
<Button x:Name="button1" Content="Add" HorizontalAlignment="Left"
VerticalAlignment="Top" Width="75" Margin="49,262,0,0" Click="button1_Click"
Height="24"/>
<Button x:Name="button2" Content="Update" HorizontalAlignment="Left"
VerticalAlignment="Top" Width="75" Margin="163,262,0,0" Click="button2_Click"
Height="24"/>
<Button x:Name="button3" Content="Delete" HorizontalAlignment="Left"
VerticalAlignment="Top" Width="75" Margin="279,262,0,0" Click="button3_Click"
Height="24"/>
.... ....
</Grid>
</Grid>
</Window>

```

Although we are not going to understand the markup from WPF point of view, let's quickly inspect it from the XML point of view.

The markup has the `Window` root element indicating that it's a window. There are certain namespaces as used by the WPF applications. Two of them are worth knowing because you will find them in every WPF XAML document:

- <http://schemas.microsoft.com/winfx/2006/xaml/presentation> is the main WPF namespace. It contains all the WPF classes, including the controls used on the user interfaces. As you can see, it is the default namespace for the entire XAML document.
- <http://schemas.microsoft.com/winfx/2006/xaml> is the XAML namespace. It has the namespace prefix of `x`. It includes various XAML features that are needed by all the applications.

The `x:Class` attribute specifies that a C# class named `MainWindow` is going to contain the code such as event handlers. The `MainWindow` class inherits from `Window` class (indicated by the `<Window>` element). This class is often called a code-behind class.

The `<Grid>` section acts as a layout scheme for the container for the WPF controls housed in the window. Inside, there are markup elements such as `<ComboBox>`, `<Label>`, `<TextBox>`, and `<Button>` that represent the respective user interface elements. Each of the elements has its own set of attributes (such as `Content`, `Text`, `HorizontalAlignment`, `VerticalAlignment`, and `Margin`).

These elements actually map to certain classes defined by the WPF framework and are often called *backing types*. For example, the `<Button>` element maps to the `System.Windows.Controls.Button` class. The `Margin` and `FontSize` attributes of the `<Button>` element correspond to the `Margin` and `FontSize` properties of the `Button` class, respectively.

So far so good. Now, let's see how to add event handlers to the buttons. Double-click on any of the `Button` controls to open the `MainWindow` class (the `MainWindow.xaml.cs` file) and the `Click` event handler of that button. The `Click` event handler of `button1` (Add) is shown in Listing 12-2.

Listing 12-2. Click Event Handler of the Button Control

```
public partial class MainWindow : Window
{
    public MainWindow()
    {
        InitializeComponent();
    }

    private void button1_Click(object sender, RoutedEventArgs e)
    {
        //your code here
    }
}
```

The `button1_Click()` method represents the `Click` event handler of the button. After generating this empty event handler, look at the XAML markup again.

```
<Button x:Name="button1"
Content="Add"
HorizontalAlignment="Left"
VerticalAlignment="Top"
Width="75"
Margin="49,262,0,0"
Click="button1_Click"
Height="24"/>
```

As you can see that `Click` attribute has been added to the `<Button>` element that points to the `Click` event handler.

As mentioned, we won't discuss the code responsible for the working this application since it is quite similar to the example you developed in Chapter 2. You can get the complete source code from the book's source code download. You may even copy and paste the event handler code into your project to make the application work as expected.

When you compile the application the XAML markup is translated into a CLR type and is merged with the code-behind class (notice that the code-behind class is a partial class) to form a single unit of code. You can now run the application and see if it works as expected.

Displaying XML Data in a WPF Application

In the preceding section, you learned that WPF uses XAML to define its user interface elements. However, it would be more interesting to see how XML data can be displayed in WPF applications. To see how that's done, you build another WPF application, as shown in Figure 12-5.

EmployeeID	FirstName	LastName	HomePhone	Notes
1	Nancy	Davolio	(206) 555-9857	Education includes a BA in ps
2	Andrew	Fuller	(206) 555-9482	Andrew received his BTS com
3	Janet	Leverling	(206) 555-3412	Janet has a BS degree in cher

Figure 12-5. Employee XML data displayed in a grid

The application's user interface consists of a DataGrid that displays XML data from the Employees.xml file. The DataGrid has five columns that display EmployeeID, FirstName, LastName, HomePhone, and Notes.

To develop this application, create a new WPF project as before and drag and drop a Grid control on it. Then configure a resource for the grid (not to be confused with DataGrid), as shown in Listing 12-3.

Listing 12-3. Configuring XmlDataProvider

```
<Grid.Resources>
  <XmlDataProvider x:Key="EmployeeData"
    Source="Employees.xml"
    XPath="/employees/employee"/>
</Grid.Resources>
```

A resource is an object that you want to use often in an application. Here you configure XmlDataProvider as a resource. An XmlDataProvider object can point to an XML file or contain inline XML data. In our example, the employee data is stored in Employees.xml file and hence the Source property of the XmlDataProvider is set to Employees.xml. The key specifies a name by which a resource is identified, EmployeeData in this case. The XPath property specifies an XPath query that gives us the desired data. In this case, we want to fill grid rows with data from the <employee> nodes. So, the XPath query is set to / employees/employee.

Drag and drop a DataGrid control from the toolbox and change its XAML (you can do that using the XAML Editor pane of the designer) to resemble Listing 12-4.

Listing 12-4. DataGrid Columns Are Bound to XML Data

```
<DataGrid x:Name="grid1" DataContext="{StaticResource EmployeeData}"
  ItemsSource="{Binding XPath=/employees/employee}"
  AutoGenerateColumns="False" HorizontalAlignment="Stretch"
  VerticalAlignment="Stretch">
  <DataGrid.Columns>
    <DataGridTextColumn Header="EmployeeID"
      Binding="{Binding XPath=@employeeid}" />
    <DataGridTextColumn Header="FirstName"
      Binding="{Binding XPath=firstname}" />
    <DataGridTextColumn Header="LastName"
      Binding="{Binding XPath=lastname}" />
    <DataGridTextColumn Header="HomePhone"
      Binding="{Binding XPath=homephone}" />
```

```
<DataGridTextColumn Header="Notes"
    Binding="{Binding XPath=notes}" />
</DataGrid.Columns>
</DataGrid>
```

The `DataContext` property of the `DataGrid` is set to `XmlDataProvider` (static resource simply means that the resource under consideration is resolved at the time of loading rather than at runtime).

Also notice that the `DataGrid` has five columns as defined by the `DataGridTextColumn` elements. The `EmployeeID` column binds to the `employeeid` attribute of the `<employee>` elements and hence its binding property is configured to use the `XPath` query `@employeeid`. Similarly, the other four columns are data bound to the `firstname`, `lastname`, `homephone`, and `notes` elements.

Note The data binding syntax used by WPF may look slightly odd if you haven't worked with WPF before. Although we won't go into the details of this syntax in this book, you can read the MSDN documentation to learn more.

Once the XAML markup is ready, run the application and see if the `DataGrid` is filled with the employee data.

Using XML in ASP.NET

`ASP.NET` is a framework for building dynamic and data-driven web applications. In `ASP.NET`, web pages are called *Web Forms*. Web Forms use the `.aspx` extension and contain HTML markup, server control markup, and optionally code. Every Web Form is a class that inherits directly or indirectly from the `System.Web.UI.Page` base class.

Note Your `ASP.NET` applications may use Web Forms or MVC. You may also use the new framework—`ASP.NET Core`—to build web applications. The discussion and examples discussed in the following sections use `ASP.NET` Web Forms. My aim is merely to show you how `ASP.NET` uses XML and XML-based syntax in several places. So, when I say `ASP.NET`, I mean `ASP.NET` Web Forms.

Server controls are object-oriented wrappers over traditional HTML elements. They are processed by `ASP.NET` on the server side, which is why they are called server controls. They provide many advantages over traditional HTML controls, including rich functionality, data binding, object-oriented features, and many others. An `ASP.NET` web site is a collection of Web Forms and related resources such as images, `JavaScript` files, and compiled components.

XML and ASP.NET

ASP.NET uses XML in several places. Some of the main areas where XML is used extensively are as follows:

- Server control markup
- XML data source control
- Navigational controls such as TreeView, Menu, and SiteMap
- XML control
- Web site configuration

You learn about all these features in the following sections.

Server Control Markup

As mentioned previously, ASP.NET Web Forms primarily consist of HTML and server control markup. The server control markup is actually a special vocabulary of XML. Each server control has a predefined tag name, tag prefix, and attributes. Some server controls are empty elements (they do not contain any child elements), whereas others can contain markup or text.

To better understand server controls, you will develop an ASP.NET web site with a Web Form. The Web Form represents a typical Contact Us page. The page will be used by end users to contact you with any questions, feedback, or comments about your web site.

Creating a Web Site

To create a new web site using Visual Studio, you need to choose the File ► New ► Web Site menu option. This option opens the New Web Site dialog box shown in Figure 12-6.

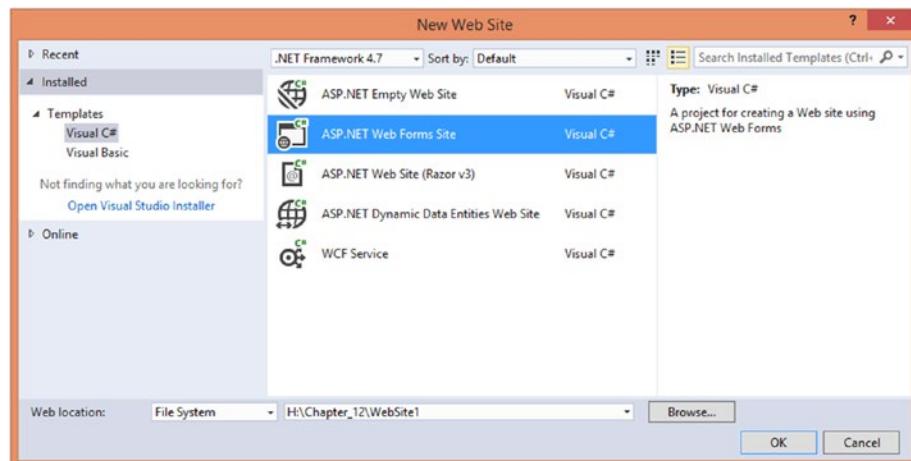


Figure 12-6. Creating a new web site

The ASP.NET Web Forms Site template allows you to create a web site. The Web location dropdown list indicates the target location where the web site will be created. Possible locations are file system, web server (HTTP), and FTP folder (FTP). In our example, we will choose file system. The path specified after the Location dropdown is the target folder where the web site will be created. Make sure to select Visual C# as the language. Click the OK button to create the web site. Visual Studio will create the web site with a certain folder structure and there will also be a Web Form named Default.aspx.

Note In most of our examples, we don't need various items created by the default project template. You may simply remove them from the project to reduce the clutter. You may also use ASP.NET Empty Web Site project template to create an empty project and add the items as needed.

Designing the Web Form

The next task is to design the Contact Us Web Form. To do so, switch to Design view, choose Table ► Insert Table from the menu, and insert a table with 11 rows and 2 columns in the default Web Form. Now you need to drag and drop various controls and arrange them in the cells of this table, as detailed in the following steps. Figure 12-7 shows Default.aspx after the designing is complete.

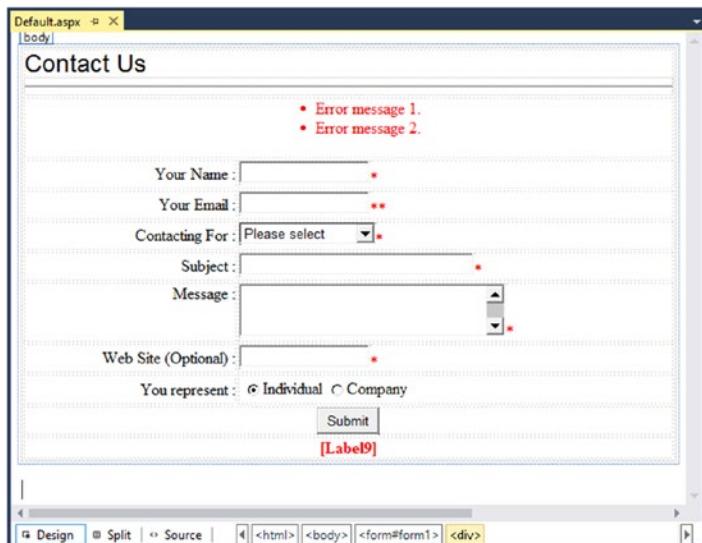


Figure 12-7. Designing a Web Form

The Web Form consists of many server controls such as Label, TextBox, DropDownList, RadioButtonList, Button, RequiredFieldValidator, RegularExpressionValidator, and ValidationSummary. To begin designing the Web Form, use the following steps:

1. Drag and drop a Label control to the first row of the table. Set its Text property to **Contact Us**. Set its Font property to your choice. Also, drag and drop a Horizontal Rule HTML control below the Contact Us label.
2. Drag and drop a ValidationSummary control in the second row. The ValidationSummary control is available in the Validation node of the toolbox and is used to display a consolidated list of validation errors from the current Web Form.
3. Drag and drop seven Label controls in rows 3 through 9. Set their Text properties to **Your Name :**, **Your Email :**, **Contacting For :**, **Subject :**, **Message :**, **Web Site (Optional) :**, and **You represent :**, respectively.
4. Drag and drop a TextBox control after the Your Name, Your Email, Subject, Message, and Web Site (Optional) labels, respectively. Set the TextMode property of the Message text box to **MultiLine**.
5. Drag and drop a DropDownList control after the Contacting For label.
6. Drag and drop a RadioButtonList after the You Represent label.
7. Drag and drop a Button control to row 10 and set its Text property to **Submit**.
8. Drag and drop a Label control to row 11 and set its Text property to a blank string. This label will be used to display a success message to the user.
9. Select the DropDownList control. Open its property window and locate the Items property. Add four items in the DropDownList: **Please Select**, **Sales Quotation**, **Technical Problem**, and **Other**.
10. Select the RadioButtonList control. Open its property window and locate the Items property. Add two items in the RadioButtonList: **Individual** and **Company**.
11. Drag and drop a RequiredFieldValidator control in front of the controls that accept a name, e-mail, reason for contact, subject, and message. The RequiredFieldValidator control is used to validate that the control to which it has been attached contains some value. Set the ControlToValidate property of all the RequiredFieldValidator controls to the ID property of the respective text boxes or **DropDownList**.
12. Set the InitialValue property of the RequiredFieldValidator attached to the Contacting For dropdown to **Please Select**. This way, the user will need to choose an option other than Please Select.

13. Drag and drop a RegularExpressionValidator control in front of the controls that accept an e-mail and web site. The RegularExpressionValidator control validates the entered value for a specific pattern. The pattern is set by using regular expression syntax. Set the ControlToValidate property of both the RegularExpressionValidator controls to the ID property of the respective text boxes. Set the ValidationExpression property of the first RegularExpressionValidator control to **Internet Email Address**. Similarly, set the ValidationExpression property of the second RegularExpressionValidator control to **Internet URL**.
14. Set the Text property of all the validation controls (RequiredFieldValidator and Regular-ExpressionValidator) to *. This text will be displayed in place of the validation control whenever there is a validation error. Also, set the ErrorMessage property of all the validation controls to some meaningful error message. The ErrorMessage will be displayed in the ValidationSummary control in the event of any validation error.

Our Web Form design is now over. At the bottom of the Web Form Designer, you will find a tab named Source. Click on it to see the markup generated for our Web Form. The relevant markup of Default.aspx is shown in Listing 12-5.

Listing 12-5. Server Control Markup from Default.aspx

```
<%@ Page Language="C#" AutoEventWireup="true"
CodeFile="Default.aspx.cs" Inherits="_Default" %>

<!DOCTYPE html>

...
<form id="form1" runat="server">
...
<asp:Label ID="Label1" runat="server" Font-Names="Arial"
Font-Size="X-Large" Text="Contact Us">
</asp:Label>
...
<asp:ValidationSummary ID="ValidationSummary1" runat="server" />
...
<asp:Label ID="Label2" runat="server" Text="Your Name :"></asp:Label>
...
<asp:TextBox ID="TextBox1" runat="server"></asp:TextBox>
<asp:RequiredFieldValidator
    ID="RequiredFieldValidator1"
    runat="server" ControlToValidate="TextBox1"
    Display="Dynamic"
    ErrorMessage="Please enter your name">*
</asp:RequiredFieldValidator>
...
<asp:Label ID="Label3" runat="server" Text="Your Email :"></asp:Label>
...
<asp:TextBox ID="TextBox2" runat="server"></asp:TextBox>
<asp:RequiredFieldValidator
    ID="RequiredFieldValidator2" runat="server"
    ControlToValidate="TextBox2"
```

```

        Display="Dynamic"
        ErrorMessage="Please enter your email">*
</asp:RequiredFieldValidator>
<asp:RegularExpressionValidator
    ID="RegularExpressionValidator1"
    runat="server"
    ControlToValidate="TextBox2"
    Display="Dynamic"
    ErrorMessage="Please enter a valid email address"
    ValidationExpression="\w+([-.\'])\w+@\w+([-.\'])\w+([-.\'])\w+)*">*
</asp:RegularExpressionValidator></td>
...
<asp:Label ID="Label4" runat="server" Text="Contacting For :"></asp:Label>
...
<asp:DropDownList ID="DropDownList1" runat="server">
<asp:ListItem Value=" Please select ">Please select</asp:ListItem>
<asp:ListItem Value=" Sales Quotation ">Sales Quotation</asp:ListItem>
<asp:ListItem Value=" Technical Problem ">Technical Problem</asp:ListItem>
<asp:ListItem Value=" Other ">Other</asp:ListItem>
</asp:DropDownList>
<asp:RequiredFieldValidator ID="RequiredFieldValidator3" runat="server"
ControlToValidate="DropDownList1" Display="Dynamic"
ErrorMessage="Please select a reason for contacting us"
InitialValue="PS">*
</asp:RequiredFieldValidator>
...
<asp:Label ID="Label5" runat="server" Text="Subject :"></asp:Label>
...
<asp:TextBox ID="TextBox3" runat="server" Columns="37"></asp:TextBox>
<asp:RequiredFieldValidator
    ID="RequiredFieldValidator4" runat="server" ControlToValidate="TextBox3"
    Display="Dynamic" ErrorMessage="Please enter subject">*
</asp:RequiredFieldValidator>
...
<asp:Label ID="Label6" runat="server" Text="Message :"></asp:Label>
...
<asp:TextBox ID="TextBox4" runat="server" Columns="30" Rows="3"
TextMode="MultiLine"></asp:TextBox>
<asp:RequiredFieldValidator
ID="RequiredFieldValidator5" runat="server" ControlToValidate="TextBox4"
Display="Dynamic" ErrorMessage="Please enter message">*
</asp:RequiredFieldValidator>
...
<asp:Label ID="Label7" runat="server" Text="Web Site (Optional) :"></asp:Label>
...
<asp:TextBox ID="TextBox5" runat="server"></asp:TextBox>
<asp:RegularExpressionValidator
    ID="RegularExpressionValidator2" runat="server" ControlToValidate="TextBox5"
    Display="Dynamic" ErrorMessage="Please enter a valid URL"
    ValidationExpression="http(s)?://([\w-]+\.)+[\w-]+(/[\w- ./?%&=]*)?">*
*</asp:RegularExpressionValidator>
...

```

```

<asp:Label ID="Label8" runat="server" Text="You represent :"></asp:Label>
...
<asp:RadioButtonList ID="RadioButtonList1" runat="server"
RepeatDirection="Horizontal">
<asp:ListItem Selected="True" Value="Individual">Individual</asp:ListItem>
<asp:ListItem Value="ListItem">Company</asp:ListItem>
</asp:RadioButtonList>
...
<asp:Button ID="Button1" runat="server" OnClick="Button1_Click" Text="Submit" />
...
<asp:Label ID="Label9" runat="server" Font-Bold="True" ForeColor="Red"></asp:Label>
...
</html>

```

Observe the markup carefully. At the top, you have a directive called @Page. A directive gives information about some entity to the ASP.NET processing engine. The @Page directive gives details about the current Web Form such as language of coding, code filename, and the class from the code file that represents this Web Form.

Next, there is a <!DOCTYPE> declaration that indicates that this document is an HTML5 document.

If you observe further, you will notice that every server control is represented by special XML markup. For example, a Label control is represented by an <asp:Label> tag, and a TextBox control is represented by an <asp:TextBox> tag. The part prior to the colon (:)—in other words, asp—is called a *tag prefix*. The part after the colon—Label or TextBox—is called a *tag name*.

Each server control has its ID attribute set to a unique value. The ID of a control is used to access it programmatically. Similarly, every server control has a runat attribute, which must have the value of server and indicates that the tag is server control markup. You will also observe that all the properties that you set via the Properties window are represented either as attributes or child elements in the server control markup. Thus ASP.NET server control markup is a special vocabulary of XML.

Writing Code

In this section, you will write some code so that when a user enters valid data and clicks the Submit button, the data is e-mailed to you. To accomplish this requirement, you need to handle the Click event of the Submit button. Double-click on Submit and you will be taken to the code-behind file (Default.aspx.cs), where you can write the code. Listing 12-6 shows the Web Form class and the skeleton of the Click event handler. We'll fill that in next.

Listing 12-6. Web Form Class and the Click Event Handler

```

public partial class _Default : System.Web.UI.Page
{
    protected void Button1_Click(object sender, EventArgs e)
    {
    }
}

```

The code-behind file contains a partial class named _Default that inherits from the System.Web.UI.Page base class, which provides basic functionality to your Web Form. Remember that the @Page directive has an attribute called Inherits that refers to this class. The _Default class is marked as partial because only when the markup file (.aspx) and code-behind file (.cs) are combined, the complete class is generated. This

merging happens at runtime and is the job of the ASP.NET Framework. Also, notice several namespaces that are imported at the top of the code-behind file. All the namespaces that start with `System.Web` are physically located in an assembly, `System.Web.dll`. This is the main assembly for ASP.NET Web Forms.

Note A thorough discussion of ASP.NET server controls and related concepts is beyond the scope of this book. If you are interested in ASP.NET web application development using Web Forms, consider visiting <https://www.asp.net/web-forms> to learn more.

To code the functionality, you need to import two namespaces: `System.Net` and `System.Net.Mail`. The latter namespace provides classes for sending e-mails. Listing 12-7 shows the `Click` event handler after adding the necessary code.

Listing 12-7. Sending E-Mail from the Code-Behind File

```
protected void Button1_Click(object sender, EventArgs e)
{
    SmtpClient client = new SmtpClient("localhost");
    client.Credentials = CredentialCache.DefaultNetworkCredentials;
    MailMessage msg = new MailMessage();
    msg.From = new MailAddress(TextBox2.Text);
    msg.To.Add("user@localhost");
    msg.Subject = TextBox3.Text;
    msg.Body =
        "[" + DropDownList1.SelectedItem.Text + "]" + TextBox4.Text + "\r\n" +
        TextBox1.Text + "\r\n" + TextBox5.Text;
    client.Send(msg);
    Label9.Text = "Your message has been sent. Thank you!";
}
```

The code declares an object of the `SmtpClient` class. The `SmtpClient` class allows you to send e-mails based on Simple Mail Transfer Protocol (SMTP). The constructor of the `SmtpClient` class accepts the IP address or name of the machine used for SMTP operations. In our example, it is assumed that you are using a local installation of IIS for sending e-mails and hence `localhost` is passed as the parameter. The `Credentials` property of the `SmtpClient` class indicates the network credentials of a user for authenticating the sender. The `DefaultNetworkCredentials` property of the `CredentialCache` class indicates the authentication credentials of the current Windows user.

After the credentials have been set, a new `MailMessage` is created. The `MailMessage` class represents an e-mail message. The `From` and `To` properties of this class represent the sender and receiver, respectively, and are of type `MailAddress` (make sure to change the e-mail address to suit your setup). The `Subject` and `Body` properties indicate the subject and body of the e-mail, respectively. All these properties are assigned by using the values entered in various Web Form controls. Finally, the `Send()` method of the `SmtpClient` class sends the supplied `MailMessage` to one or more recipients. A success message is displayed in a label informing the user that the message has been received.

Running the Web Application

To run the web application that you just finished, you need to choose the Debug ► Start Debugging menu option (or just press F5). Visual Studio will start the development web server in the background and will host your web site in it. It will also open a browser and load the Default.aspx. Figure 12-8 shows the Default.aspx Web Form in the browser.

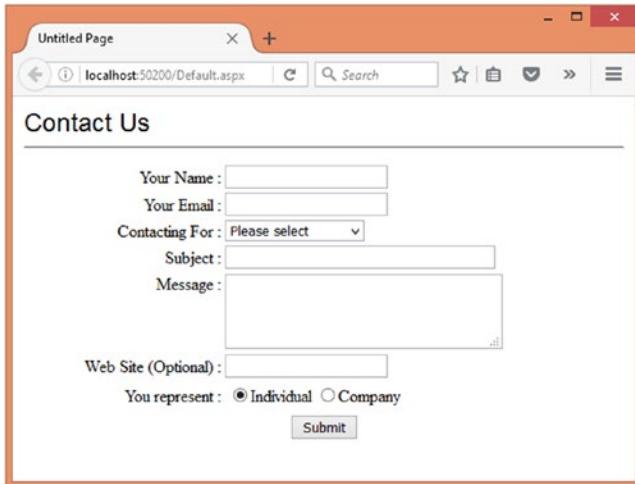


Figure 12-8. Default.aspx in a browser

If you try to click the Submit button without entering any values, you should see validation error messages, as shown in Figure 12-9.

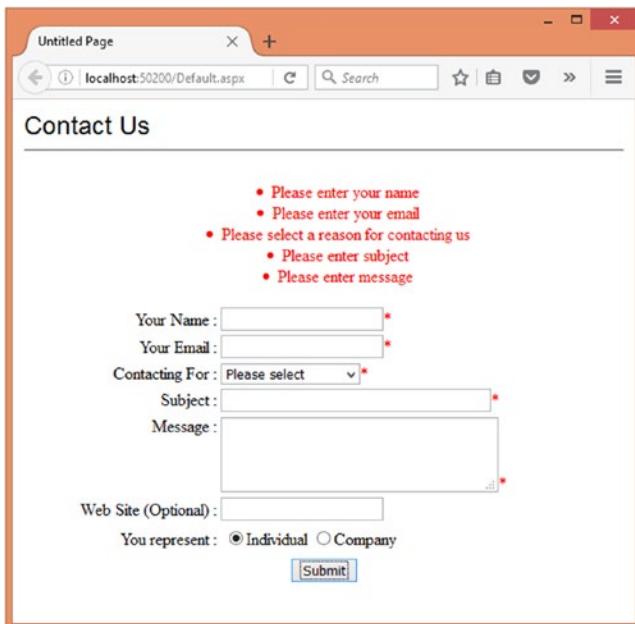


Figure 12-9. Web form showing validation errors

Notice how the ValidationSummary displays a collective list of error messages, whereas an asterisk is displayed in place of individual validation controls. If you enter valid values in the controls and click Submit, the code will send an e-mail to your e-mail address and will display a success message, as shown in Figure 12-10.

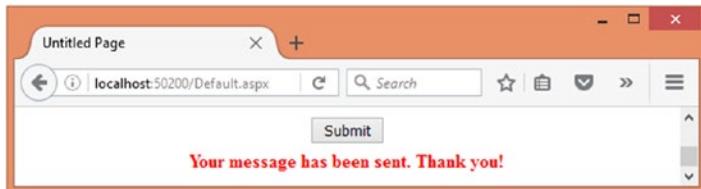


Figure 12-10. Successful execution of the Web Form

Note Since this was the first ASP.NET example, I outlined all the steps required to develop and run the application. Now that you are familiar with the web site projects, future examples focus on the primary topic being discussed, skipping detailing of these steps.

The XML Data Source Control

One of the strengths of server controls is their ability to perform data binding with relational or hierarchical data. ASP.NET data source controls are a set of web server controls that automate common data-access tasks such as fetching records and displaying them in other data bound controls. All of this is achieved without any code being written by the developer. As we are looking at XML in this book, it is the XML data source control we are interested in. This control is very useful when you are using server controls such as TreeView that essentially display hierarchical data. Let's see how the XML data source control can be used along with a TreeView control.

Begin by creating a new web site via Visual Studio. Add a new XML file to your web site by using the Add New Item dialog box and name it *Navigation.xml*. The *Navigation.xml* file contains XML markup representing the web site navigation structure. The XML markup from *Navigation.xml* is shown in Listing 12-8.

Listing 12-8. XML Markup from the *Navigation.xml* File

```
<?xml version="1.0" encoding="utf-8" ?>
<node text="Home" url="default.aspx">
    <node text="Products" url="products.aspx">
        <node text="Product 1" url="product1.aspx"></node>
        <node text="Product 2" url="product2.aspx"></node>
        <node text="Product 3" url="product3.aspx"></node>
    </node>
    <node text="Services" url="services.aspx">
        <node text="Service 1" url="service1.aspx"></node>
        <node text="Service 2" url="service2.aspx"></node>
        <node text="Service 3" url="service3.aspx"></node>
    </node>
    <node text="About Us" url="about.aspx"></node>
    <node text="Contact Us" url="contact.aspx"></node>
</node>
```

The root tag of the document is `<node>`, which further contains various `<node>` tags. Each `<node>` element represents a node of the TreeView control and has two attributes, `text` and `url`:

- The `text` attribute specifies the text to be displayed in the TreeView node.
- The `url` attribute points to a URL where the user should be navigated.

The nesting of the `<node>` elements decides the nesting of the TreeView rendered. Thus the root node of the TreeView will be Home. The Home node will have four immediate children: Products, Services, About Us, and Contact Us. Similarly, the Products and Services nodes will have three children each.

Now drag and drop an `XmlDataSource` control from the toolbox onto the Web Form Designer. Set its `DataFile` property to `Navigation.xml`. The `DataFile` property points to an XML file that will be supplying data to the XML data source control. Next, drag and drop a `TreeView` control onto the Web Form and set its `DataSourceID` property to the ID of the `XmlDataSource` control you just configured. Now locate the `DataBindings` property of the `TreeView` and open the `TreeView DataBindings Editor` (see Figure 12-11).

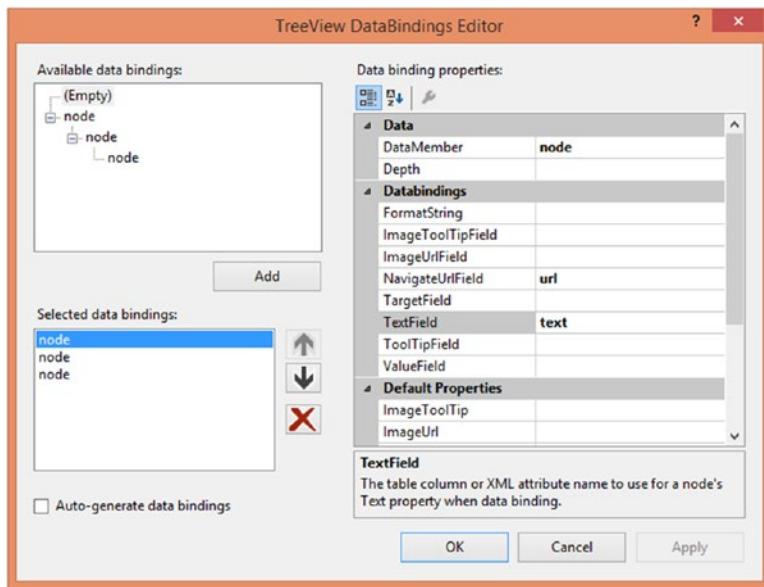


Figure 12-11. *TreeView DataBindings Editor*

In the Available Data Bindings area, you will see all the nodes at each level from the XML file. Select the node at each level and click the Add button. You will now have three entries in the Selected Data Bindings area. Select the first data binding and set its `TextField` and `NavigateUrlField` properties to `text` and `url`, respectively. As you might have guessed, `text` and `url` are the attributes of the `<node>` element. The `DataMember` property indicates the name of the element from the XML document that is supplying the data and is automatically set to `node`. Repeat the same process for the remaining two data bindings. Listing 12-9 shows the complete markup of `Default.aspx`.

Listing 12-9. Markup Containing the XmlDataSource and the TreeView

```
<%@ Page Language="C#" AutoEventWireup="true" CodeFile="Default.aspx.cs"
Inherits="_Default" %>

<!DOCTYPE html>

<html xmlns="http://www.w3.org/1999/xhtml" >
  <head runat="server">
    <title>Untitled Page</title>
  </head>
  <body>
    <form id="form1" runat="server">
      <asp:XmlDataSource ID="XmlDataSource1" runat="server"
        DataFile("~/Navigation.xml")>
      </asp:XmlDataSource>
      <asp:TreeView ID="TreeView1" runat="server" AutoGenerateDataBindings="False"
        DataSourceID="XmlDataSource1" Font-Bold="True" Font-Size="Large"
        ShowLines="True">
        <DataBindings>
          <asp:TreeNodeBinding DataMember="node" NavigateUrlField="url"
            TextField="text" />
          <asp:TreeNodeBinding DataMember="node" NavigateUrlField="url"
            TargetField="text" />
          <asp:TreeNodeBinding DataMember="node" NavigateUrlField="url"
            TargetField="text" />
        </DataBindings>
      </asp:TreeView>
    </form>
  </body>
</html>
```

As you can see, the XML data source control and the TreeView control are represented by the `<asp:XmlDataSource>` and `<asp:TreeView>` markup tags, respectively. Each TreeView node binding is represented by an `<asp:TreeNodeBinding>` tag. The `DataMember`, `NavigateUrlField`, and `TextField` attributes of the `TreeNodeBinding` element represent the properties that you assigned previously.

Now run the web site as before and see how the TreeView control renders the various nodes based on the structure specified in the `Navigation.xml` file. Figure 12-12 shows a sample run of the Web Form.

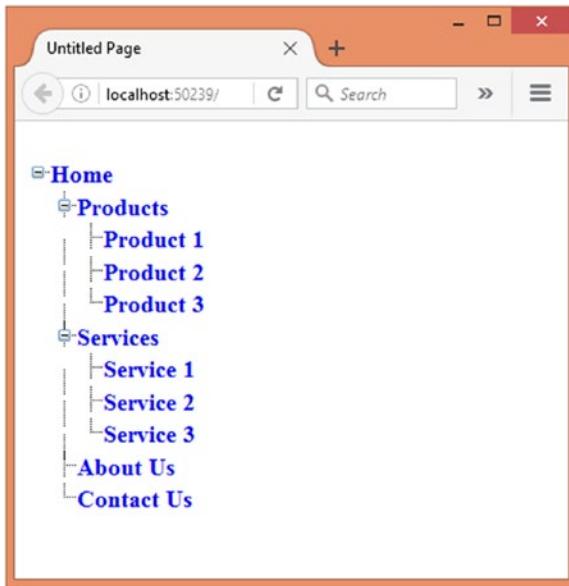


Figure 12-12. A TreeView populated by using an XML data source control

Applying Transformations

In the preceding example, you supplied the XML file as is to the XML data source control. What if you want to apply an XSLT transformation to the XML file and then bind it with the TreeView? Fortunately, the XML data source control has a built-in facility to do just that: the `TransformFile` property, which points to an XSLT file. Before supplying the XML data to other controls such as a TreeView, the XSLT style sheet is applied to the XML data and then the transformed data is passed on. Suppose that you bound a TreeView control to an XML document, as shown in Listing 12-10.

Listing 12-10. XML Document to Be Bound to a TreeView

```
<?xml version="1.0" encoding="utf-8"?>
<MenuItem Title="Home" URL="default.aspx">
  <MenuItem Title="Products" URL="products.aspx">
    <MenuItem Title="Product 1" URL="product1.aspx" />
    <MenuItem Title="Product 2" URL="product2.aspx" />
    <MenuItem Title="Product 3" URL="product3.aspx" />
  </MenuItem>
  <MenuItem Title="Services" URL="services.aspx">
    <MenuItem Title="Service 1" URL="service1.aspx" />
    <MenuItem Title="Service 2" URL="service2.aspx" />
    <MenuItem Title="Service 3" URL="service3.aspx" />
  </MenuItem>
  <MenuItem Title="About Us" URL="about.aspx" />
  <MenuItem Title="Contact Us" URL="contact.aspx" />
</MenuItem>
```

As you can see, this XML document uses the `<MenuItem>` element to represent a TreeView node. The `Title` and `URL` attributes represent the `Text` and `NavigateUrlField` properties of individual TreeView nodes. Now suppose that for some reason, you want to bind the same TreeView to another XML document, as shown in Listing 12-11.

Listing 12-11. XML Markup from the New XML File

```
<?xml version="1.0" encoding="utf-8" ?>
<node text="Home" url="default.aspx">
    <node text="Products" url="products.aspx">
        <node text="Product 1" url="product1.aspx"></node>
        <node text="Product 2" url="product2.aspx"></node>
        <node text="Product 3" url="product3.aspx"></node>
    </node>
    <node text="Services" url="services.aspx">
        <node text="Service 1" url="service1.aspx"></node>
        <node text="Service 2" url="service2.aspx"></node>
        <node text="Service 3" url="service3.aspx"></node>
    </node>
    <node text="About Us" url="about.aspx"></node>
    <node text="Contact Us" url="contact.aspx"></node>
</node>
```

You might have noticed that this is the same XML file that we used in the previous example. To cater to the change, you need to reconfigure the TreeView node data bindings to suit the new XML document. If the underlying data binding has complex nesting, this may not be an easy task. This situation can be avoided if you apply an XSLT style sheet to the XML from Listing 12-11 and transform it to match the XML in Listing 12-10. The XSLT style sheet that can do this transformation is shown in Listing 12-12.

Listing 12-12. An XSLT Style Sheet for Transforming the New XML Markup

```
<?xml version="1.0" encoding="UTF-8" ?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
    <xsl:template match="/">
        <xsl:for-each select=".">
            <xsl:apply-templates/>
        </xsl:for-each>
    </xsl:template>
    <xsl:template match="node">
        <xsl:element name="MenuItem">
            <xsl:attribute name="Title">
                <xsl:value-of select="@text"/>
            </xsl:attribute>
            <xsl:attribute name="URL">
                <xsl:value-of select="@url"/>
            </xsl:attribute>
            <xsl:apply-templates />
        </xsl:element>
    </xsl:template>
</xsl:stylesheet>
```

The style sheet transforms a <node> element to a <MenuItem> element. Further, it transforms the text and url attributes to the Title and URL attributes, respectively.

To test how the TransformFile property works, you need to modify the preceding example by following these steps:

1. Add a new XSLT file named `Navigation.xslt` to the web site.
2. Key in the markup shown in Listing 12-12.
3. Set the `TransformFile` property of the XML data source control to `Navigation.xslt`.
4. Open the TreeView DataBindings Editor of the TreeView and modify the data bindings to use the MenuItem node as `DataMember`, Title as `TextField`, and URL as `NavigateUrlField`.

This time, the TreeView DataBindings Editor looks like Figure 12-13.

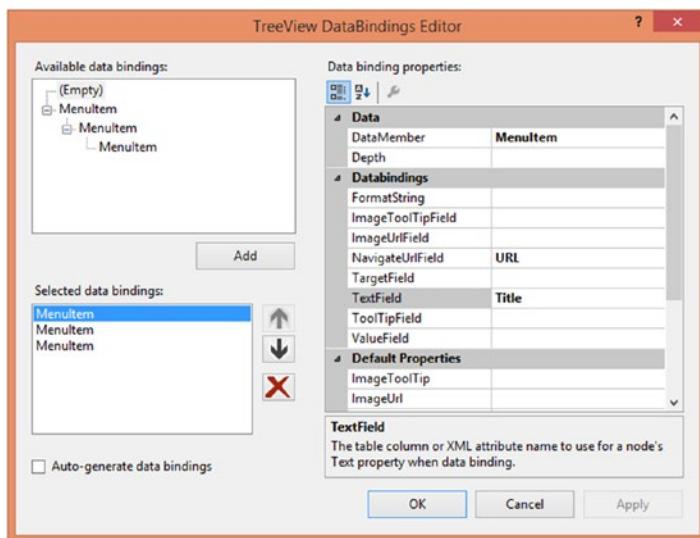


Figure 12-13. TreeView DataBindings Editor showing transformed nodes

You will observe that although the `DataFile` property is still `Navigation.xml`, the data bindings shown are as per the transformation specified in the XSLT style sheet. If you run the Web Form again, the output should be the same as in Figure 12-12 earlier.

Filtering Data by Using XPath Expressions

At times you may want to filter the data from the source XML file and bind the filtered data to other controls. This is where the `XPath` property of the XML data source control comes in. The `XPath` property takes a valid XPath expression and applies it to the source XML data.

Suppose, for example, that you want to display only product-related nodes in the TreeView. You can achieve this by setting the `XPath` property of the XML data source to `/node/node[@text="Products"]`. This way, only the product-related nodes (Products, Product 1, Product 2, and Product 3) will be filtered. The TreeView will have nesting up to two levels only (Products as the top node, and the other three nodes as child nodes). Figure 12-14 shows a sample run of the same Web Form after setting the `XPath` property.

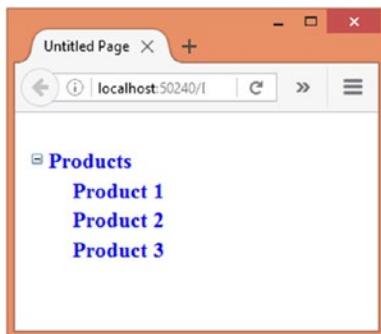


Figure 12-14. TreeView after applying the XPath filter

Binding an XML Data Source to a Menu Control

In the previous examples, you used a TreeView to display data supplied by an XML data source control. ASP.NET also provides a Menu control that can be used to display hierarchical data. The Menu control closely matches the TreeView control with respect to XML data binding. However, it differs in its look and feel. The Menu control renders dynamic pulldown menus in your Web Forms similar to traditional Windows applications. Let's see an example of how it can be used.

Create a new web site in Visual Studio. Add the `Navigation.xml` file that you created previously to the web site by using the Add Existing Item dialog box. Drag and drop an `XmlDataSource` control onto the default Web Form and set its `DataFile` property to `Navigation.xml`. Now drag and drop a `Menu` control onto the form and set its `DataSourceID` property to the ID of the `XmlDataSource` control you just configured.

Now, locate the `Menu` control's `DataBindings` property. Similar to the `TreeView`, the `Menu` control opens the `Menu DataBindings Editor`, wherein you can configure the data bindings.

The process of configuring data bindings is exactly the same as before. You need to select the required data bindings and set their `DataMember`, `TextField`, and `NavigateUrl` properties to `node`, `text`, and `url`, respectively. Figure 12-15 shows the `Menu DataBindings Editor` with required data bindings added.

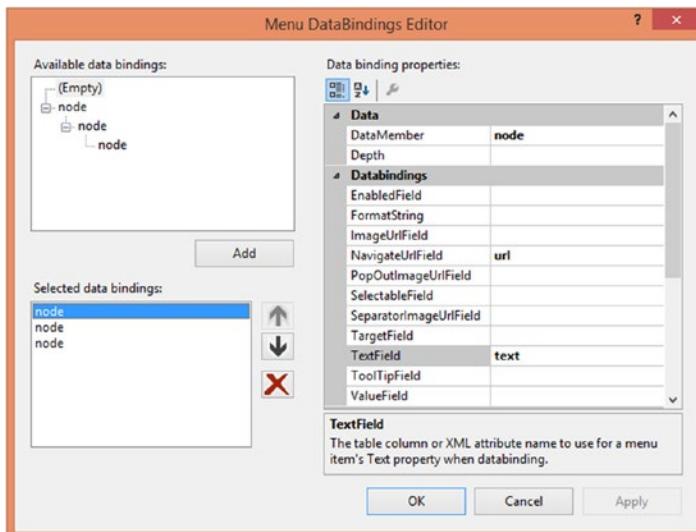


Figure 12-15. Menu DataBindings Editor

The complete markup of the Web Form is shown in Listing 12-13.

Listing 12-13. Markup of the Menu Control

```
<%@ Page Language="C#" AutoEventWireup="true" CodeFile="Default.aspx.cs"
   Inherits="_Default" %>

<!DOCTYPE html>
<html xmlns="http://www.w3.org/1999/xhtml" >
  <head runat="server">
    <title>Untitled Page</title>
  </head>
  <body>
    <form id="form1" runat="server">
      <asp:XmlDataSource ID="XmlDataSource1" runat="server"
        DataFile("~/Navigation.xml")></asp:XmlDataSource>
      <asp:Menu ID="Menu1" runat="server" BackColor="#E3EAEB"
        DataSourceID="XmlDataSource1">
        <DataBindings>
          <asp:MenuItemBinding DataMember="node" NavigateUrlField="url"
            TextField="text" />
          <asp:MenuItemBinding DataMember="node" NavigateUrlField="url"
            TextField="text" />
          <asp:MenuItemBinding DataMember="node" NavigateUrlField="url"
            TextField="text" />
        </DataBindings>
      </asp:Menu>
    </form>
  </body>
</html>
```

As you can see, the Menu control is represented by the `<asp:Menu>` markup tag. The `<DataBindings>` section defines one or more data bindings, where each data binding is represented by an `<asp:MenuItemBinding>` element. Running the Web Form should render the menu as shown in Figure 12-16.

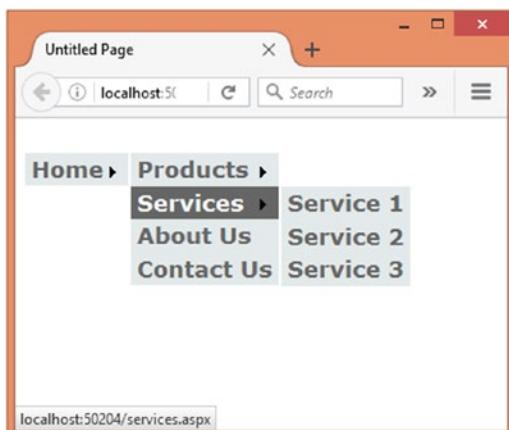


Figure 12-16. The Menu control in action

Working with Site Maps

A *site map* is an XML file that details the overall navigational layout of your web site. You can then consume this site map file as required. The site map file has an extension of `.sitemap`. Let's examine site map files via an example. Have a look at Figure 12-17.

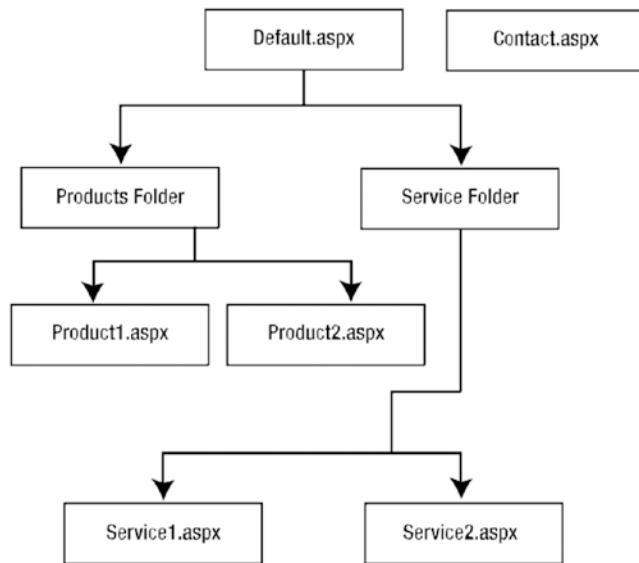


Figure 12-17. Structure of a web site

Figure 12-17 shows the directory structure of a sample web site. The home page (`Default.aspx`) and Contact Us page (`Contact.aspx`) reside in the root folder of the web site. There are two subfolders called Products and Services. Each of them contains two Web Forms—`Product1.aspx` and `Product2.aspx`, and `Service1.aspx` and `Service2.aspx`—respectively. Now let's represent this web site structure by using a site map.

Create a new web site by using Visual Studio. Add a new site map file by using the Add New Item dialog box (see Figure 12-18). Name the site map file `Web.sitemap`.

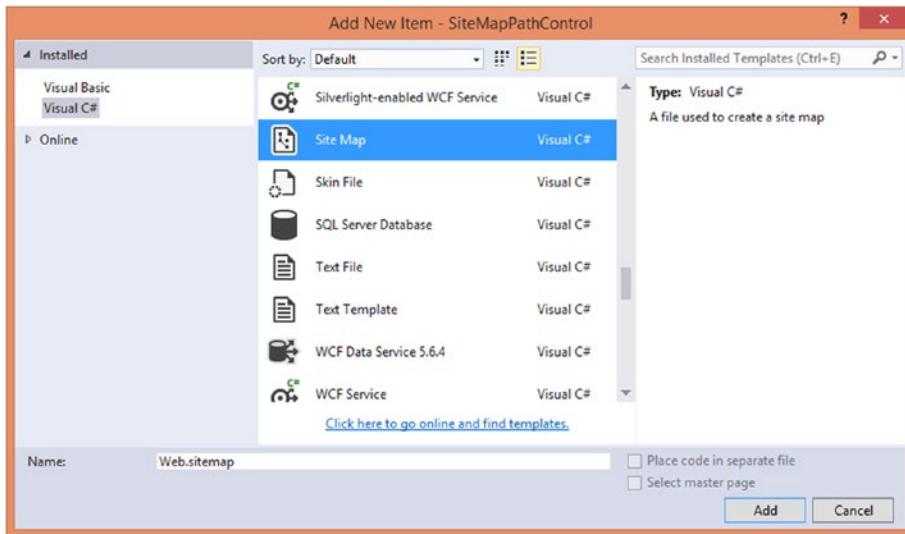


Figure 12-18. Adding a new site map

Now type the XML markup shown in Listing 12-14 into the Web.sitemap file.

Listing 12-14. Contents of the Web.sitemap File

```
<?xml version="1.0" encoding="utf-8" ?>
<siteMap xmlns="http://schemas.microsoft.com/AspNet/SiteMap-File-1.0" >
<siteMapNode url="default.aspx" title="Home" description="My Web Site">
  <siteMapNode url("~/products/default.aspx" title="Products">
    <siteMapNode url "~/products/product1.aspx" title="First Product" />
    <siteMapNode url "~/products/product2.aspx" title="Second Product" />
  </siteMapNode>
  <siteMapNode url "~/services/default.aspx" title="Services">
    <siteMapNode url "~/services/service1.aspx" title="First Service" />
    <siteMapNode url "~/services/service2.aspx" title="Second Service" />
  </siteMapNode>
<siteMapNode url="contact.aspx" title="Contact Us" />
</siteMapNode>
</siteMap>
```

The site map file contains a set of predefined tags and attributes. The root node of a site map file is `<siteMap>`. It further contains several `<siteMapNodes>` tags depending on your web site structure. The `<siteMapNode>` tag has four important attributes. They are listed in Table 12-1.

Table 12-1. Attributes of a Site Map Node

Attribute	Description
title	Indicates the title of the page. This attribute is often used by navigational controls to display the title for the URL.
url	Indicates the URL of the page that this node represents.
description	Specifies the description of the destination page. You can use this description to show ToolTips.
roles	While using security trimming, this attribute specifies the roles that are allowed to access this page.

Note *Security trimming* is a feature that implements role-based security by rendering only the nodes that are allowed for the current user. In other words, a particular `<siteMapNode>` will be accessible to a user only if the user's role is specified in the `roles` attribute of the `<siteMapNode>` element.

Site map files are often used to render some kind of navigational structure. There are two common ways in which you can consume the site map file you just created:

- In a `SiteMapPath` control
- In a `SiteMapDataSource` control

In the following sections, you are going to see both of them.

Using a SiteMapPath Control

The `SiteMapPath` control allows you to render what are often called *breadcrumbs*. Figure 12-19 shows what breadcrumbs are.

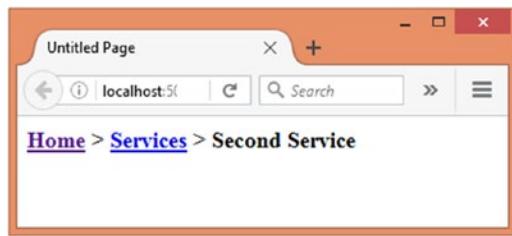


Figure 12-19. Breadcrumbs

The `SiteMapPath` control displays various levels of navigation. You can click on the parent or root levels to navigate back or to the top level. Before we delve into the details, let's first create the required directory structure and Web Forms. Begin by adding two folders to the web site called Products and Services. Add the Web Forms as shown in Table 12-2.

Table 12-2. Folders and Web Forms

Web Form Name	Folder
Default.aspx	Root folder
Contact.aspx	Root folder
Product1.aspx	Products
Product2.aspx	Products
Service1.aspx	Services
Service2.aspx	Services

Now drag and drop a SiteMapPath control onto each Web Form. Run Service2.aspx in the browser, and you should see something similar to Figure 12-19. The SiteMapPath control automatically renders breadcrumbs for the current Web Form based on its location in the site map file.

Using a SiteMapDataSource Control

The use of site maps is not limited just to the SiteMapPath control. You can also attach the site map to navigational controls such as a TreeView. In this example, we will use the same site map file to bind to a TreeView.

Create a new web site by using Visual Studio. Add the same Web.sitemap file to it. This time drag and drop a SiteMapDataSource control onto the Web Form. The SiteMapDataSource control automatically picks up the Web.sitemap file and supplies it to other controls. Further, drag and drop a TreeView control and set its DataSourceID property to the ID attribute of the SiteMapDataSource. That's it. Run the Web Form, and it should resemble Figure 12-20.

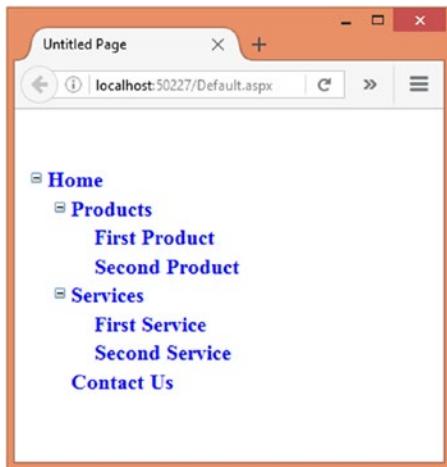


Figure 12-20. TreeView bound with SiteMapDataSource control

Using the XML Control

In Chapter 6, you learned to apply XSLT style sheets to XML data and transform them from one vocabulary to another. You achieved this by creating an instance of the `XslCompiledTransform` class. You then loaded an XSLT style sheet into it by using its `Load()` method. Finally, you did the transformation by using its `Transform()` method. ASP.NET provides an easy alternative to this manual coding: the XML control. The XML control accepts an XML document and XSLT style sheet. It then applies the style sheet to the XML data and renders the content on the web page. The most common use of the XML control is to transform XML data into HTML, though of course it doesn't have to be HTML.

To illustrate the use of the XML control, create a new web site. Add a new XML file named `Employees.xml` and type in the markup shown in Listing 12-15.

Listing 12-15. XML File That Supplies Data to the XML Control

```
<?xml version="1.0" encoding="utf-8" ?>
<?xml-stylesheet type="text/xsl" href="Employees.xslt"?>
<!-- This is list of employees --&gt;
&lt;employees&gt;
    &lt;employee employeeid="1"&gt;
        &lt;firstname&gt;Nancy&lt;/firstname&gt;
        &lt;lastname&gt;Davolio&lt;/lastname&gt;
        &lt;homephone&gt;(206) 555-9857&lt;/homephone&gt;
        &lt;notes&gt;
            &lt;![CDATA[Education includes a BA in psychology from Colorado State University in 1970.
                She also completed "The Art of the Cold Call." Nancy is a member of Toastmasters
                International.]]&gt;
        &lt;/notes&gt;
    &lt;/employee&gt;
    &lt;employee employeeid="2"&gt;
        &lt;firstname&gt;Andrew&lt;/firstname&gt;
        &lt;lastname&gt;Fuller&lt;/lastname&gt;
        &lt;homephone&gt;(206) 555-9482&lt;/homephone&gt;
        &lt;notes&gt;
            &lt;![CDATA[Andrew received his BTS commercial in 1974 and a Ph.D. in
                international marketing from the University of Dallas in 1981. He is fluent in
                French and Italian and reads German. He joined the company as a sales
                representative, was promoted to sales manager in January 1992 and to vice
                president of sales in March 1993. Andrew is a member of the Sales Management
                Roundtable, the Seattle Chamber of Commerce, and the Pacific Rim Importers
                Association.]]&gt;
        &lt;/notes&gt;
    &lt;/employee&gt;
    &lt;employee employeeid="3"&gt;
        &lt;firstname&gt;Janet&lt;/firstname&gt;
        &lt;lastname&gt;Leverling&lt;/lastname&gt;
        &lt;homephone&gt;(206) 555-3412&lt;/homephone&gt;
        &lt;notes&gt;
            &lt;![CDATA[Janet has a BS degree in chemistry from Boston College (1984).&lt;/notes&gt;
        &lt;/employee&gt;
    &lt;/employees&gt;</pre>

```

```

She has also completed a certificate program in food retailing management.
Janet was hired as a sales associate in 1991 and promoted to sales
representative in February 1992.]]>
  </notes>
</employee>
</employees>
```

Similarly, add a new XSLT style sheet named Employees.xsl and type in the markup shown in Listing 12-16.

Listing 12-16. XSLT Style Sheet to Be Applied

```

<?xml version="1.0" encoding="UTF-8" ?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
  <xsl:template match="/">
    <html>
      <body>
        <h1>Employee Listing</h1>
        <table border="1">
          <tr>
            <th>Employee ID</th>
            <th>First Name</th>
            <th>Last Name</th>
            <th>Home Phone</th>
            <th>Notes</th>
          </tr>
          <xsl:for-each select="employees/employee">
            <tr>
              <td>
                <xsl:value-of select="@employeeid"/>
              </td>
              <td>
                <xsl:value-of select="firstname"/>
              </td>
              <td>
                <xsl:value-of select="lastname"/>
              </td>
              <td>
                <xsl:value-of select="homephone"/>
              </td>
              <td>
                <xsl:value-of select="notes"/>
              </td>
            </tr>
          </xsl:for-each>
        </table>
      </body>
    </html>
  </xsl:template>
</xsl:stylesheet>
```

Note These are the same files that you used in Chapter 6. If you want, you can add them to your web site instead of recreating them.

Now drag and drop an XML control onto the default Web Form. Set its DocumentSource property to Employees.xml and its TransformSource property to Employees.xsl. The former property points to the XML file that is to be transformed, whereas the latter property points to the XSLT style sheet that is to be applied to the DocumentSource. Now run the Web Form and you should see something similar to Figure 12-21.

Employee ID	First Name	Last Name	Home Phone	Notes
1	Nancy	Davolio	(206) 555-9857	Education includes a BA in psychology from Colorado State University in 1970. She also completed "The Art of the Cold Call." Nancy is a member of Toastmasters International.
2	Andrew	Fuller	(206) 555-9482	Andrew received his BTS commercial in 1974 and a Ph.D. in international marketing from the University of Dallas in 1981. He is fluent in French and Italian and reads German. He joined the company as a sales representative, was promoted to sales manager in January 1992 and to vice president of sales in March 1993. Andrew is a member of the Sales Management Roundtable, the Seattle Chamber of Commerce, and the Pacific Rim Importers Association.
				Janet has a BS degree in chemistry from Boston

Figure 12-21. XML data transformed to HTML by using the XML control

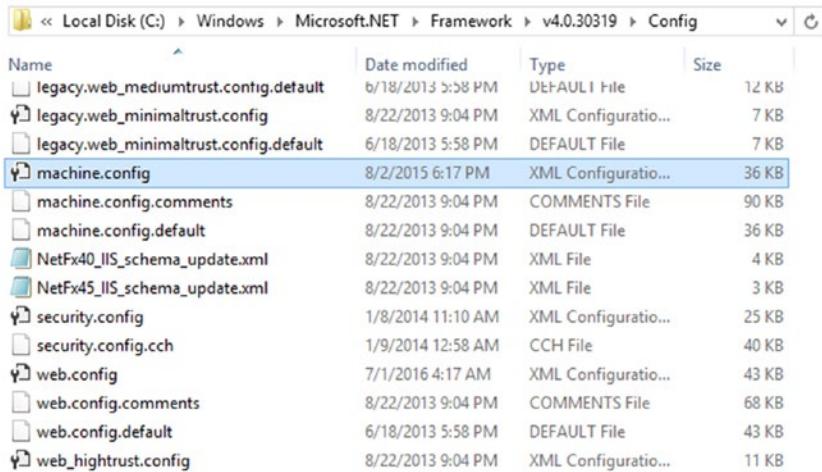
Using the .NET Framework Configuration System

The .NET Framework's configuration system heavily relies on XML files. There are two distinct XML files that store .NET Framework's configuration:

- Machine configuration files
- Application configuration files

When you install the .NET Framework on a machine, an XML file named Machine.config gets created in the <installation_path>/Config folder. The Machine.config file is the master configuration file and contains configuration settings that are applied to all .NET applications running on that machine.

Though this file is in XML format and can be edited directly, you should do so with caution. That's because any change made to this file is going to affect all the applications running on that machine. Figure 12-22 shows location of Machine.config in a sample installation.



Name	Date modified	Type	Size
legacy.web_mediumtrust.config.default	6/18/2013 5:58 PM	DEFAULT File	12 KB
legacy.web_minimaltrust.config	8/22/2013 9:04 PM	XML Configuration...	7 KB
legacy.web_minimaltrust.config.default	6/18/2013 5:58 PM	DEFAULT File	7 KB
machine.config	8/2/2015 6:17 PM	XML Configuration...	36 KB
machine.config.comments	8/22/2013 9:04 PM	COMMENTS File	90 KB
machine.config.default	8/22/2013 9:04 PM	DEFAULT File	36 KB
NetFx40_IIS_schema_update.xml	8/22/2013 9:04 PM	XML File	4 KB
NetFx45_IIS_schema_update.xml	8/22/2013 9:04 PM	XML File	3 KB
security.config	1/8/2014 11:10 AM	XML Configuration...	25 KB
security.config.cch	1/9/2014 12:58 AM	CCH File	40 KB
web.config	7/1/2016 4:17 AM	XML Configuration...	43 KB
web.config.comments	8/22/2013 9:04 PM	COMMENTS File	68 KB
web.config.default	6/18/2013 5:58 PM	DEFAULT File	43 KB
web_hightrust.config	8/22/2013 9:04 PM	XML Configuration...	11 KB

Figure 12-22. Location of Machine.config

To override settings specified in the `Machine.config` file, you need to create application configuration files. Application configuration files are also XML files containing special XML markup. For Windows-based applications, the application configuration file is of the form `<exe_name>.exe.config`, where `exe_name` is the name of the application executable.

Note While developing windows applications in Visual Studio, you will find that there is `App.config` file in the project's root folder. This file holds the development time application configuration. The `<exe_name>.exe.config` can be found in the `Bin\Debug` or `Bin\Release` folders. You should deploy `<exe_name>.exe.config` along with your application and not the `App.config` file.

For web applications, the application configuration filename must be `web.config`. In the following sections, you are going to learn more about the `web.config` file and the XML vocabulary used therein.

Note There are also security configuration files that store Code Access Security related configuration. These files are supposed to be changed using the Code Access Security Policy tool (`Caspol.exe`). It is recommended that you alter these files only if you are aware of the impact they are going to have on security policy. We won't go into any details of security configuration files in this book.

Structure of the web.config File

Listing 12-17 shows the general structural outline of a `web.config` file.

Listing 12-17. Structural Outline of `web.config`

```
<configuration>
    <appSettings />
    <connectionStrings />
    <system.web />
</configuration>
```

As you can see, the root node of the `web.config` file is `<configuration>`, and there are three main subsections:

- The `<appSettings>` section is used to specify application configuration settings.
- The `<connectionStrings>` section is used to store one or more database connection strings.
- The `<system.web>` section contains all the settings applicable to web applications.

All of these sections are optional. However, in most real-world cases you will have at least the `<system.web>` section.

Note The `web.config` file contains many configuration sections. It isn't possible to cover every section here. I am going to discuss some commonly used sections only.

Web.config Inheritance

The `web.config` file exhibits what is often referred to as *inheritance behavior*. In a single web application, there can be one or more `web.config` files in different folders. The settings of one `web.config` file are applied to the folder in which it resides and all the subfolders. However, if the subfolders contain a `web.config` of their own, the settings specified in that `web.config` take precedence.

Using Web.config for Common Configuration Tasks

Now that we have a basic understanding of how `web.config` works, let's see how to perform some common configuration tasks. We are briefly going to cover the following tasks in particular:

- How to store and retrieve application configuration settings
- How to store and retrieve your database connection strings
- How to work with forms authentication
- How to deal with session state
- How to provide custom error pages in your web site

Storing and Retrieving Application Configuration Settings

Avoiding hard-coding values is a mandatory requirement in many real-world applications. Earlier in this chapter, we developed a Contact Us Web Form that sent messages from users to a specified e-mail address. In that example, we hard-coded an e-mail address in the code-behind file. What if the e-mail address changes after deployment? Obviously, you need to change the source code to match the new e-mail address and redeploy the application. This is not a recommended practice for real-world applications. Wouldn't it be nice if we could isolate the e-mail address from the application, store it in an external location, and retrieve it inside your code? Prior to .NET Framework, developers achieved this by using .INI files or the registry. In .NET, you have a nice alternative: the application configuration section of configuration files.

The `<appSettings>` section of `web.config` allows you to store such application-specific settings. You can then read these settings in your source code. If the settings change after deploying the application, you need to change just the `web.config` file and not the source code. Let's modify our Contact Us Web Form to use application configuration settings.

Note Although the example discussed here uses the `<appSettings>` section in a web application, `<appSettings>` is equally applicable to Windows applications.

Open the same web site by choosing **File ▶ Open ▶ Web Site** from the menu. Open the `web.config` file and modify the `<appSettings>` section, as shown in Listing 12-18.

Listing 12-18. Storing Values in the `<appSettings>` Section

```
<appSettings>
  <add key="host" value="localhost"/>
  <add key="email" value="user@localhost"/>
</appSettings>
```

The `<appSettings>` section can contain one or more `<add>` elements. The `<add>` element has two attributes:

- The `key` attribute defines a key with which the value will be accessed in the code.
- The `value` attribute specifies the actual value of the key.

In our example, we defined two keys: `host` and `email`. The former key stores the value of the SMTP host, and the latter stores your e-mail address. Now open the code-behind of the Web Form and modify the `Click` event handler of the Submit button, as shown in Listing 12-19.

Listing 12-19. Retrieving Values from the `<appSettings>` Section

```
protected void Button1_Click(object sender, EventArgs e)
{
  string host = ConfigurationManager.AppSettings["host"];
  string email = ConfigurationManager.AppSettings["email"];
  SmtpClient client = new SmtpClient(host);
  client.Credentials = CredentialCache.DefaultNetworkCredentials;
  MailMessage msg = new MailMessage();
  msg.From = new MailAddress(TextBox2.Text);
  msg.To.Add(email);
  msg.Subject = TextBox3.Text;
```

```

msg.Body =
    "[" + DropDownList1.SelectedItem.Text + "]" + TextBox4.Text + "\r\n" +
    TextBox1.Text + "\r\n" + TextBox5.Text;
client.Send(msg);
Label9.Text = "Your message has been sent. Thank you!";
}

```

Observe the code marked in bold. The code uses a class called `ConfigurationManager`, which resides in the `System.Configuration` namespace. By default, `System.Configuration` is imported in the code-behind. The `AppSettings` property of the `ConfigurationManager` class exposes the entire `<appSettings>` section as a `NameValueCollection`. You can access individual values by using an index or a key name, though it is more common to access them by using key names.

The code retrieves the values of two keys—`host` and `email`—and stores them in a string variable. The constructor of the `SmtpClient` class now accepts the value stored in the `host` string variable instead of a hard-coded value. Similarly, the `Add()` method accepts the value stored in the `email` string variable and not a hard-coded value. If you run the application, you should get the results as before, but now you are free to change the host name and e-mail address without touching the source code.

Storing and Retrieving Database Connection Strings

Storing database connection strings outside the source code is probably the most common configuration task. The configuration file has a special section to store database connection strings called `<connectionStrings>`. The `<connectionStrings>` section allows you to store one or more database connection strings that can be retrieved later in your code. To retrieve the connection strings stored in the `<connectionStrings>` section, you again need to use the `ConfigurationManager` class.

To illustrate the use of the `<connectionStrings>` section, you will develop a simple employee listing Web Form. The Web Form will display a list of employees in a `GridView` control. To begin, create a new web site by using Visual Studio as before.

Note Although the example discussed here uses the `<connectionStrings>` section in a web application, `<connectionStrings>` is equally applicable to Windows applications.

Open the `web.config` file in the IDE and modify the `<connectionStrings>` section, as shown in Listing 12-20.

Listing 12-20. Adding a Connection String to the `<connectionStrings>` Section

```

<connectionStrings>
    <add name="northwind"
        connectionString="data source=.;initial catalog=Northwind;
        integrated security=true"
        providerName="System.Data.SqlClient"/>
</connectionStrings>

```

The `<connectionStrings>` section can contain one or more `<add>` elements, each defining a database connection string:

- The `name` attribute of the `<add>` element defines a name for that connection string. This name is used later to access the connection string.
- The `ConnectionString` attribute specifies the actual database connection string.
- Finally, the `providerName` attribute indicates the .NET data provider that can be used to communicate with the database.

Now open the default Web Form and drag and drop a `GridView` control onto it. Then type in the code shown in Listing 12-21 in the `Page_Load` event of the Web Form.

Listing 12-21. Retrieving the Connection String

```
protected void Page_Load(object sender, EventArgs e)
{
    string strConn=
        ConfigurationManager.ConnectionStrings["northwind"].ConnectionString;
    SqlDataAdapter da =
        new SqlDataAdapter("SELECT EmployeeID, FirstName, LastName FROM Employees",
                          strConn);
    DataSet ds = new DataSet();
    da.Fill(ds, "employees");
    GridView1.DataSource = ds;
    GridView1.DataBind();
}
```

The code uses the `ConfigurationManager` class to retrieve the connection string value. The `ConnectionStrings` collection can be accessed by using an index or a connection string name. In our example, we access it with a name.

Each connection string stored in the `<connectionStrings>` section is represented by a `ConnectionStringSettings` class, and the `ConnectionString` property of this class returns the actual connection string. The connection string is then used as the second parameter of the `SqlDataAdapter` constructor, the first parameter being the `SELECT` query.

A `DataSet` is then filled by using the `Fill()` method of the `SqlDataAdapter` class. The `DataSet` thus created acts as a `DataSource` to the `GridView` control. The `.DataBind()` method of the `GridView` control binds the data from the `DataSet` to the `GridView`. If you run the Web Form after writing the code, you should see something similar to Figure 12-23.

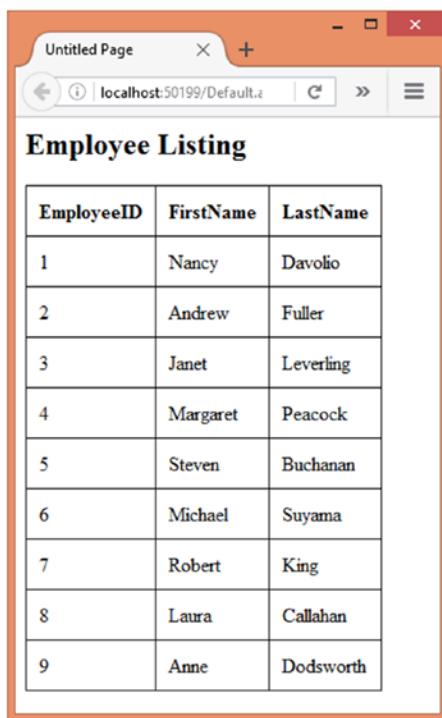


Figure 12-23. Web Form displaying an employee listing

Using Forms Authentication

While developing web sites, you may need to ensure that pages be accessible only to valid users of the application. Moreover, you may want that only the users belonging to certain role (say, Administrator) be allowed to access the pages. The later is often called *role-based security*. To implement such security features, you use authentication and authorization.

Authentication is a process by which you decide whether a person is a valid user of the application. Typically this validity is determined by a combination of username and password. Authorization is a process by which you decide whether an authenticated user can access a certain page or feature. A common way to authorize users is to add them to one or more roles.

The web.config file has two sections—<authentication> and <authorization>—that allow you to configure the respective security aspects for a web site. As an example, let's build a simple web site that authenticates a user and displays a welcome message upon a successful login attempt.

Note To keep things simple, we won't implement database-driven authentication and role-based security in this example. In a realistic case, you could either use ASP.NET Membership and Roles or, better yet, ASP.NET Identity to develop a full-fledge authentication and authorization scheme for your web site.

Create a new web site using Visual Studio as before. Then open the web.config file in the IDE and add the <authentication> and <authorization> sections, as shown in Listing 12-22.

Listing 12-22. Configuring Forms Authentication

```
<authentication mode="Forms">
  <forms loginUrl("~/login.aspx"
          defaultUrl("~/default.aspx")>
  </forms>
</authentication>
<authorization>
  <deny users="?" />
</authorization>
```

The markup shown in Listing 12-22 sets the mode attribute of the `<authentication>` section to Forms. The mode attribute can take one of these values—None, Forms, Windows, Passport, and Federated. The Forms authentication is a very common form of authentication wherein a login page is presented to the user, the user enters some username and password, and then those credentials are validated against some datastore (such as SQL Server).

The `<authentication>` section contains the `<forms>` element that configures the Forms authentication. The `loginUrl` attribute of the `<forms>` tag indicates that `Login.aspx` is the login page of the application. If any user tries to access other pages without logging in first, he will be redirected to this page. The `defaultUrl` attribute of the `<forms>` tag indicates that after a successful login attempt, the user can be redirected to the default page.

The `<authorization>` section contains the `<deny>` element. The `users` attribute of the `<deny>` tag is set to ?, indicating that anonymous users should not be allowed to access the web site.

Now add two Web Forms to the project—`Default.aspx` and `Login.aspx`. Then open `Login.aspx` and drag and drop a Login control on it from the toolbox. As you might have guessed, the Login control allows you to easily capture the username and password of a user. At this stage, `Login.aspx` should look like Figure 12-24.

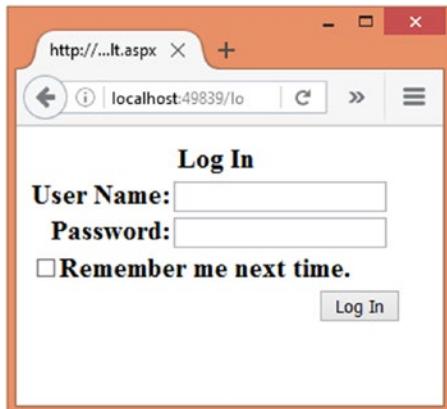


Figure 12-24. *Login.aspx with Login control*

Now double-click on the Login control to go to its `Authenticate` event handler. The `Authenticate` event handler is a place for writing your code that validates the user credentials. In a real-world case you would have a database access involved here. For the sake of simplicity, our example uses a hard-coded username and password. The `Authenticate` event handler is shown in Listing 12-23.

Listing 12-23. Authenticate Event Handler

```
protected void Login1_Authenticate(object sender, AuthenticateEventArgs e)
{
    if(Login1.UserName=="admin" && Login1.Password=="password")
    {
        FormsAuthentication.SetAuthCookie(Login1.UserName, Login1.RememberMeSet);
        e.Authenticated = true;
        Response.Redirect(FormsAuthentication.DefaultUrl);
    }
    else
    {
        e.Authenticated = false;
    }
}
```

The Authenticate event handler checks the UserName and Password properties of the Login control. If they are admin and password respectively then it calls the SetAuthCookie() method of the FormsAuthentication class (System.Web.Security namespace). The Forms authentication works with the help of a cookie (by default). The presence of this cookie along with a request indicates that a user is an authenticated user. Absence of this cookie indicates that the user has not yet been authenticated. The SetAuthCookie() method issues this cookie to the user. The two parameters of the SetAuthCookie() method are username and whether to remember the logged-in status even after closing the browser (persistent cookie).

Once the authentication cookie is issued, the code redirects the user to the default page. Notice how the DefaultUrl property of FormsAuthentication class is used to retrieve the defaultUrl you set earlier in the configuration file.

If the username and password don't match the specified values, the Authenticated property of the AuthenticateEventArgs class is set to false. This way, the Login control will display an error message to the user.

Next, open the Default.aspx file and drag and drop two Label controls and a Button control on it. Set the Text property of the Button to Logout. The default page will display a welcome message to the user. To specify this message, write the code shown in Listing 12-24 in the Page_Load event handler.

Listing 12-24. Retrieving the Username

```
protected void Page_Load(object sender, EventArgs e)
{
    Label1.Text = $"Welcome {Page.User.Identity.Name}!";
    if (Request.IsAuthenticated)
    {
        Label2.Text = "You are an authenticated user.";
    }
}
```

The code retrieves the name of the currently logged in user using Page.User.Identity.Name and forms a welcome message based on it. The code then checks the IsAuthenticated property of the Request object. This property indicates whether a request is authenticated. If the request is authenticated, a message is shown in the second Label.

Now, double-click on the Button control to go in its Click event handler. Write the code shown in Listing 12-25 in the Click event handler.

Listing 12-25. Logging a User Out

```
protected void Button1_Click(object sender, EventArgs e)
{
    FormsAuthentication.SignOut();
    Response.Redirect(FormsAuthentication.LoginUrl);
}
```

The code calls the `SignOut()` method of the `FormsAuthentication` class. The `SignOut()` method removes the authentication cookie issued earlier. Once the cookie is removed, the user is taken back to the login page. This is done by redirecting the control to the page, as indicated by the `LoginUrl` property of `FormsAuthentication`.

If you run the application, you will be taken to the login page shown earlier. If you enter valid credentials, the default page will be displayed as shown in Figure 12-25.

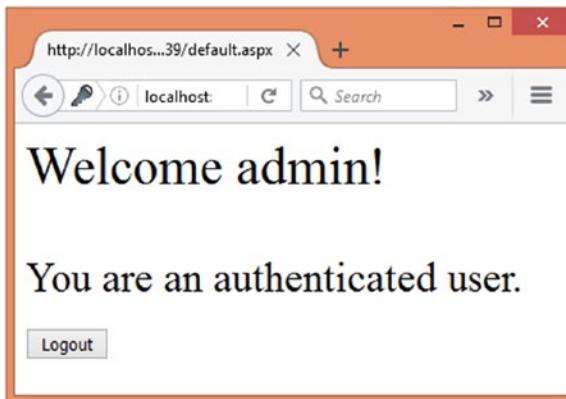


Figure 12-25. Default page displaying welcome message

As you can see, the welcome message is displaying the username. You can click on the Logout button to log out and return to the login page.

Configuring Session State

ASP.NET session allows you to store arbitrary pieces of information. Session state is maintained per user basis. Session is exposed as an intrinsic object—`Session`—that stores data as key-value pairs. To configure the behavior of the session, `web.config` has the `<sessionState>` element. Using the `<sessionState>` element you can fine-tune various aspects of session such as its storage mode, timeout, and cookieless nature.

To see how `<sessionState>` can be used, create a new ASP.NET web site as before. Open the `web.config` file and add the `<sessionState>` element, as shown in Listing 12-26.

Listing 12-26. The `<sessionState>` Element

```
<sessionState
    mode="InProc"
    timeout="2"
    cookieless="true">
</sessionState>
```

The `<sessionState>` element shown in Listing 12-26 sets the mode attribute to InProc. The mode attribute controls where the session data will be stored. The possible values are Off, InProc, StateServer, SQLServer, and Custom. If you set the mode to Off, the session is turned off and you can't store any data in the session. The value of InProc indicates that the session data is stored in the memory of the web server hosting the application. The StateServer and SQLServer modes allow you to store session state outside of the web server (we won't discuss them in this book).

The timeout attribute sets the idle time in minutes after which the session is emptied. The value of 2 means if you store some data in the session and thereafter don't use the application for 2 minutes, the data will be removed from the session. Default session timeout is 20 minutes.

By default, sessions require cookies enabled on the client browser. This cookie typically stores a session's ID. If you didn't want to use cookies for some reason, the cookieless attribute can come handy. Setting cookieless to false means that the session won't use cookies; instead ASP.NET will add something to the URL (you will see that in a minute).

Now, open Default.aspx and drag and drop a Label control on it. Then add the code shown in Listing 12-27 to the Page_Load event handler.

Listing 12-27. The Page_Load event handler

```
protected void Page_Load(object sender, EventArgs e)
{
    if(Session["timestamp"]==null)
    {
        Session["timestamp"] = DateTime.Now.ToString();
    }
    Label1.Text = Session["timestamp"].ToString();
}
```

The Page_Load event handler first checks whether Session contains a key named `timestamp`. If this key doesn't exist (the value is null), then current date and time values are stored into the session. The `timestamp` value is then assigned to the Label.

Run the web site; your Web Form should resemble Figure 12-26.

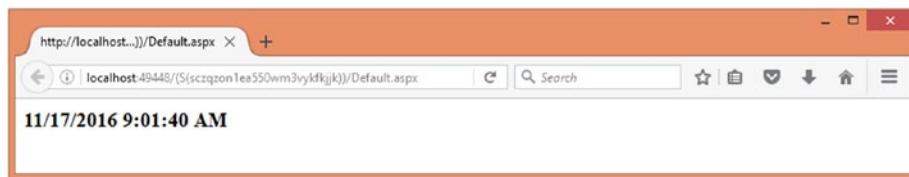


Figure 12-26. Timestamp displayed from the session

If you refresh the browser, you will find that the timestamp doesn't change. This indicates that the value stored in the session during the first run of the page is being used as expected. Now, keep the browser window idle for 3-4 minutes and then refresh it again. You will find that the timestamp has changed. This is due to the timeout value of 2 minutes. After 2 minutes of idle time, the `timestamp` key was removed from the session and hence a new timestamp was stored.

Also notice the browser's address bar. You will see some string segment inserted into the URL. This is the result of setting the `cookieless` attribute to `true`. Due to this setting, ASP.NET adds a session's ID into the URL rather than storing it in a cookie.

Displaying Custom Error Pages

Even after taking great care during the coding phase, errors can crop up at runtime in your web site. Users make typos in page URLs and try to access areas that are restricted, network failures can happen, and so on. As a robust programming practice, you should make provisions to trap all such unexpected errors. To that end, ASP.NET allows you to specify what is known as custom error pages in the `web.config` file. This is done using the `<customErrors>` element of `web.config`. Let's see how.

Create a new web site in Visual Studio. Add a new folder in it called `Admin`. This folder is supposed to contain administrative pages, and users are unauthorized to access it. Add the five Web Forms listed in Table 12-3.

Table 12-3. Web Forms Arrangement

Web Form	Folder	Description
Default.aspx	Root	The default page of the web site
FileNotFoundException.aspx	Root	Custom error page that is displayed for HTTP error code 404
UnAuthorized.aspx	Root	Custom error page that is displayed for HTTP error code 403
GlobalErrorPage.aspx	Root	Custom error page that is displayed for any other unhandled error in code or otherwise
Default.aspx	Admin	Represents the default page of the Admin folder

Now design `Default.aspx` from the root folder to look like the page shown in Figure 12-27.

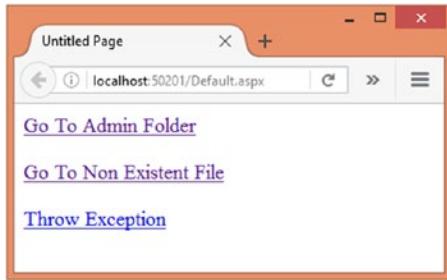


Figure 12-27. Design of `Default.aspx`

`Default.aspx` contains two hyperlink controls titled `Go to Admin Folder` and `Go to Nonexistent File`. Set the `NavigateUrl` property of these hyperlink controls to `~/admin/default.aspx` and `~/notexists.aspx`, respectively. Note that we are deliberately setting the `NavigateUrl` of the second hyperlink to a nonexistent file. Now drag and drop a `LinkButton` control and set its `Text` property to `Throw Exception`. Add the code shown in Listing 12-28 in its `Click` event handler.

Listing 12-28. Throwing an Exception

```
protected void LinkButton1_Click(object sender, EventArgs e)
{
    throw new Exception("Unexpected Error");
}
```

The code simply throws a new exception. Because this is an unhandled exception, we will get a chance to trap it by using a custom error page. Now add a Label and a HyperLink control each on `FileNotFoundException.aspx`, `UnAuthorized.aspx`, and `GlobalErrorPage.aspx`. Set the `Text` property of the Label controls to a friendly error message. Point the HyperLink to `Default.aspx` so that users can easily navigate back to the home page.

Add the code shown in Listing 12-29 in the `Page_Load` event of the `Admin/Default.aspx` Web Form.

Listing 12-29. Throwing an `HttpException`

```
protected void Page_Load(object sender, EventArgs e)
{
    throw new HttpException(403, "Unauthorized");
}
```

The code raises an `HttpException` with a status code of 403 and a string message. The `HttpException` class represents an HTTP-specific exception. This way, we trigger an exception with status code 403 (unauthorized access).

Now open `web.config` in the IDE and add the markup shown in Listing 12-30 under the `<system.web>` section.

Listing 12-30. Specifying Custom Error Pages

```
<customErrors mode="On" defaultRedirect="GlobalErrorPage.aspx">
    <error statusCode="403" redirect="~/UnAuthorized.aspx"/>
    <error statusCode="404" redirect="~/FileNotFoundException.aspx"/>
</customErrors>
```

The `<customErrors>` section allows you to specify custom error pages for your web site. The `mode` attribute has three possible values:

- If the `mode` is `On`, custom error pages are enabled for all the machines browsing the web site.
- If the `mode` is `Off`, custom error pages are disabled for all the machines.
- If the `mode` is `RemoteOnly`, the custom errors are enabled only for remote machines browsing the web site, but they are turned off for local browsers.

During development, most commonly your web server and the browser will be running on the same machine and hence you should set the `mode` to `On`.

The `defaultRedirect` attribute points to a web page that is to be displayed in case there is any application-wide unhandled error.

The `<customErrors>` section can have a number of `<error>` tags. The `statusCode` attribute of the `<error>` tag specifies the web-server-level HTTP error code. The `redirect` attribute specifies the web page to be displayed in the event of that error. In our example, we configure two custom error pages: one for status code 403 (`UnAuthorized.aspx`) and the other for status code 404 (`FileNotFoundException.aspx`).

Now run `Default.aspx` and click all three links, one by one. You will notice that instead of displaying the default error page, this time ASP.NET displays the custom error pages as specified in `web.config`. Figure 12-28 shows one sample run of the web site.

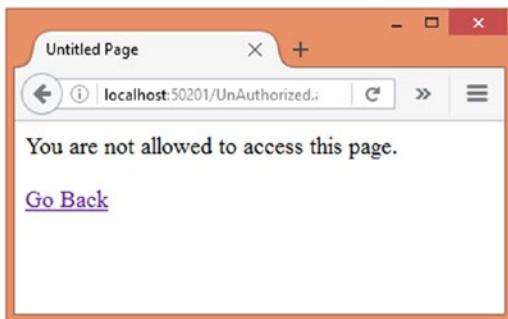


Figure 12-28. Custom error page for status code 403

Documenting Code with XML Comments

Documenting your source code is a common requirement in any professional development. Everybody knows the importance of well-documented code. However, documenting your source code is just one part of the story. Often, you also need to generate professional help files that ship along with your application and are used by the end users.

There are various ways of creating documentation and help files. Most of them are manual in that somebody (a developer or a technical writer) needs to key in the help text in HTML or PDF format. Then a tool (such as Microsoft HTML Help Workshop) is used to compile the source files into a .CHM file. That means there is duplication of work. First, developers need to write comments in the source code. Then the same information is repeated in the help files.

Fortunately, the .NET Framework and Visual Studio support a feature called XML comments. By using this feature, you can add comments to your source code by using a specific XML vocabulary. Later you can extract these XML comments in a separate XML file and transform it into HTML or some other format. Thus documentation of code is automated and avoids duplication.

In C#, XML comments are indicated by three forward slashes (///). There are several XML tags that you can use in XML comments. In the following sections, you will learn many of them.

Creating a Class Library

To begin, you need to create a class library named `XmlComments.dll`. This class library represents a simple mathematical calculator and consists of a single class called `Calculator`. The `Calculator` class allows you to add, subtract, divide, and multiply numbers. Though this example may sound too simple (and indeed it is), your aim here is to learn XML commenting syntax.

Create a new class library project in Visual Studio. Name the project `XmlComments` and the class `Calculator`. Type the code from Listing 12-31 into the `Calculator` class.

Listing 12-31. The `Calculator` Class

```
public class Calculator
{
    public int Add(int a, int b)
    {
        return (a + b);
    }
}
```

```

public int Subtract(int a, int b)
{
    return (a - b);
}
public int Divide(int a, int b)
{
    return (a / b);
}
public int Multiply(int a, int b)
{
    return (a * b);
}
}

```

The class consists of four methods: `Add()`, `Subtract()`, `Divide()`, and `Multiply()`. Each method accepts two parameters and performs the corresponding action on them. The result of the calculation is returned to the caller. Now that you have the class ready, let's add XML documentation comments to it.

Documenting the Summary and Remarks

To describe your classes and members therein, you can use two tags: `<summary>` and `<remarks>`. The `<summary>` tag is used to describe a type or its members. The `<remarks>` tag is used to specify additional information about the type or member other than that specified in `<summary>`. Listing 12-32 shows the `Calculator` class after adding `<summary>` and `<remarks>` tags.

Listing 12-32. Adding `<summary>` and `<remarks>`

```

/// <summary>
/// This is a class that represents
/// a simple mathematical calculator.
/// </summary>
/// <remarks>
/// This class is developed on .NET Framework 4.7
/// </remarks>
public class Calculator
{
...

```

Adding Paragraphs

The summary or remarks may consist of multiple paragraphs of text. Each paragraph is represented by a `<para>` tag. Note that a `<para>` tag is always a child element of `<summary>` or `<remarks>`. Listing 12-33 shows the use of a `<para>` tag.

Listing 12-33. Using a `<para>` Tag

```

/// <summary>
/// This is a class that represents
/// a simple mathematical calculator.
/// <para>
/// You can use it to add, subtract,

```

```

/// divide and multiply integers and
/// fractional numbers.
/// </para>
/// </summary>
/// <remarks>
/// This class is developed on .NET Framework 4.7
/// </remarks>

```

Documenting Method Parameters and Return Values

Methods often take one or more parameters. They might also return some value to the caller. Parameters are represented by `<param>` tags, whereas return values are represented by `<return>` tags. The `<param>` tag has one attribute—`name`—that indicates the name of the parameter. Listing 12-34 shows the use of both of these tags on the `Add()` method.

Listing 12-34. Documenting Parameters and Return Values

```

/// <summary>
/// This method adds two integers.
/// </summary>
/// <param name="a">The first number</param>
/// <param name="b">The second number</param>
/// <returns>An integer representing addition of a and b</returns>
public int Add(int a, int b)
{
    return (a + b);
}

```

Specifying Scope and Permissions

Your class may contain private, protected, or public members. The scope of these members can be indicated by using the `<permission>` tag. The `<permission>` tag has one attribute, called `cref`, that specifies the name of the member in the given context. Listing 12-35 shows an example of using the `<permission>` tag.

Listing 12-35. Using the `<permission>` Tag

```

/// <summary>
/// This method adds two integers.
/// </summary>
/// <param name="a">The first number</param>
/// <param name="b">The second number</param>
/// <returns>An integer representing addition of a and b</returns>
/// <permission cref="Add">Public method</permission>
public int Add(int a, int b)
{
    return (a + b);
}

```

Specifying Links to Other Members

You may need to cross-reference members of your class. The MSDN library itself is a good example of this. At many places, documentation of one class points to another related class. Also, at the bottom of the documentation page, there appears a section called See Also. You can achieve the same thing for your documentation by using the `<see>` and `<seealso>` tags. The `<see>` tag must be used inside the `<summary>` or `<remarks>` tags. The `<seealso>` tag has an attribute called `cref` that points to another member and can be used outside the `<summary>` tag. Listing 12-36 illustrates the use of the `<seealso>` tag as an example.

Listing 12-36. Using the `<seealso>` Tag

```
/// <summary>
/// This method adds two integers.
/// </summary>
/// <param name="a">The first number</param>
/// <param name="b">The second number</param>
/// <returns>An integer representing addition of a and b</returns>
/// <permission cref="Add">Public method</permission>
/// <seealso cref="Subtract"/>
public int Add(int a, int b)
{
    return (a + b);
}
```

Adding Lists

Your documentation may need bulleted or numbered lists. This can be achieved by using three tags: `<list>`, `<item>`, and `<listheader>`. The `<item>` and `<listheader>` tags must appear inside the `<list>` tag. The `<list>` tag has an attribute named `type` that can take a value of `bullet`, `number`, or `table`. The `<listheader>` tag serves the purpose of supplying a header for the list. Finally, the `<item>` tag encapsulates a single item of the list. Listing 12-37 shows the use of these tags.

Listing 12-37. Using the `<list>`, `<item>`, and `<listheader>` Tags

```
/// <summary>
/// This is a class that represents
/// a simple mathematical calculator.
/// <para>
/// You can use it to add, subtract,
/// divide and multiply integers and
/// fractional numbers.
/// </para>
/// <list type="bullet">
/// <listheader>Supported Operations</listheader>
/// <item>Addition</item>
/// <item>Subtraction</item>
/// <item>Division</item>
/// <item>Multiplication</item>
/// </list>
/// </summary>
/// <remarks>
```

```
/// This class is developed on .NET Framework 4.7  
/// </remarks>  
public class Calculator  
{  
    ...
```

Generating XML Documentation from Comments

To generate XML documentation from source code comments, you need to open the project properties dialog box (see Figure 12-29).

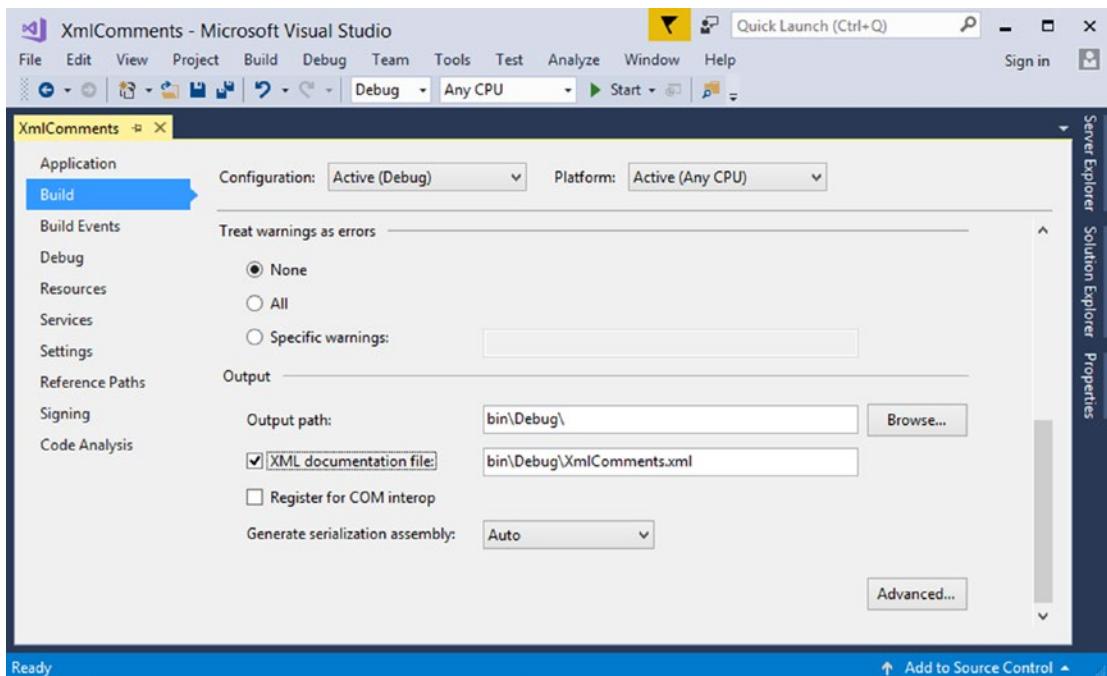


Figure 12-29. Generating XML documentation

The Output section of the Build tab allows you to specify whether to generate XML documentation and the filename. Specify the filename as `XmlComments.xml` and build the `XmlComments` class library. As a result of the compilation, you will get `XmlComments.dll` and `XmlComments.xml` in the output folder. Figure 12-30 shows `XmlComments.xml` opened in a browser.

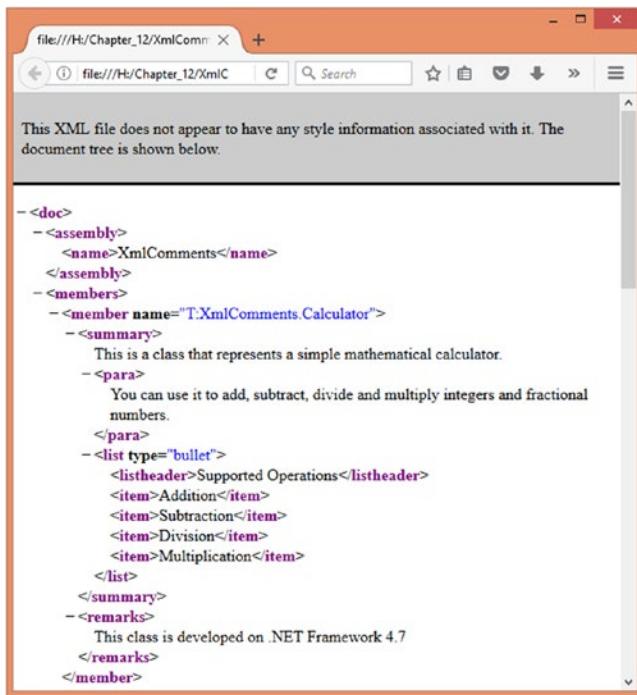


Figure 12-30. *XmlComments.xml viewed in browser*

As you might have guessed, documentation in XML is good but needs to be converted to a more readable format such as HTML or help files. There is no built-in way to do that in Visual Studio. Some of the ways to generate user-friendly documentation files include:

- Writing an XSLT style sheet that transforms XML documentation to HTML.
- Using a third-party tool that reads the XML comments or the XML documentation file and generates readable documentation for you.

In the next section, you will use the latter technique to generate documentation out of the XML comments.

Using Sandcastle Help File Builder to Generate Help Files

Sandcastle Help File Builder (SHFB) is a tool for generating documentation from the XML comments you learned in the previous section. This tool is available on GitHub at <https://github.com/EWSoftware/SHFB>. You can feed any .NET assembly to the tool and generate documentation in any of the following formats:

- HTML Help 1 (.chm)
- MS Help Viewer (.mshc)
- Open XML (.docx)
- Markdown (.md)
- HTML (.htm/.html)

In order to use SHFB, you must install it and its dependencies. The installation wizard guides you through all the steps.

Once you install SHFB, open it and create a new SHFB project by selecting File ▶ New Project. Save the newly created project in some folder. Then right-click on the Documentation Sources under the Project Explorer and pick the `XmlComments.dll` file from the previous example. Doing so indicates that you want to generate documentation from this assembly. At this stage, your SHFB window will look as shown in Figure 12-31.

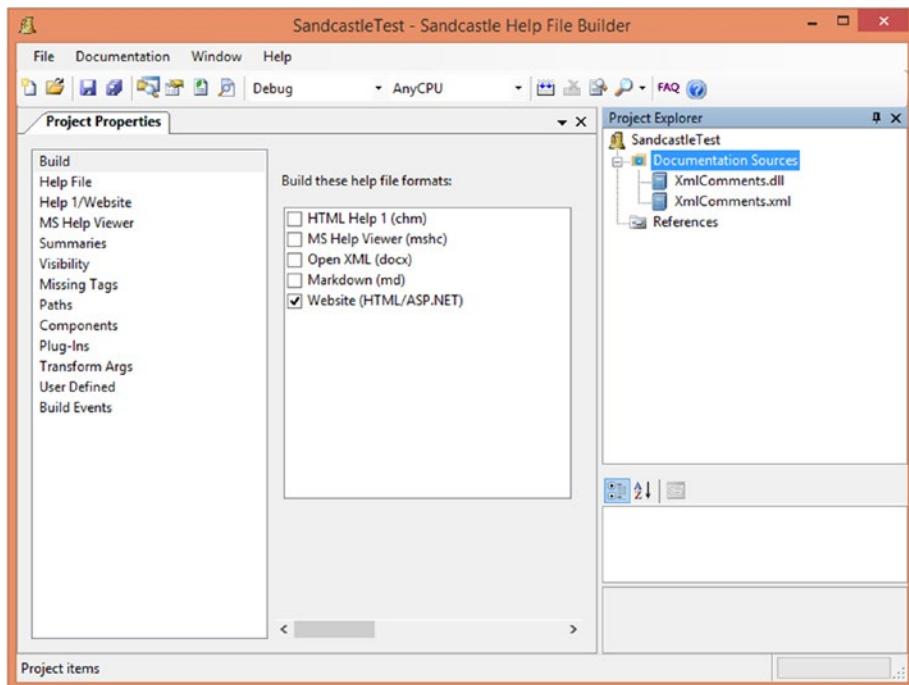


Figure 12-31. Documentation sources added to SHFB

Notice that the Documentation Sources also lists `XmlComments.xml` automatically. From the help file formats list, check the Only Website option. Selecting this option will generate documentation in HTML format and you can easily view it in any browser.

Next, select Documentation ▶ Build Project from the menu and let the tool generate the documentation for you. Once the documentation is generated, you can go to the Help folder under the SHFB project's folder and launch `Index.html` in any browser. Figure 12-32 shows the documentation generated for the `XmlComments` assembly.

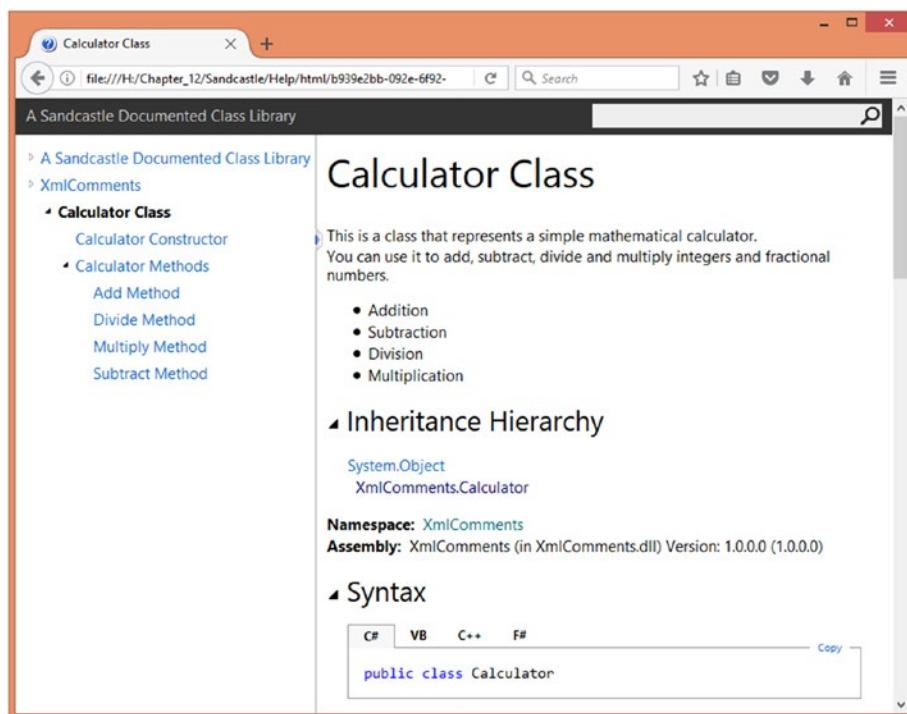


Figure 12-32. Documentation for the Calculator class

As you can see, SHFB converted your XML comments into nicely formatted and styled web pages. Try navigating to various parts of the documentation using the tree on the left.

Summary

The .NET Framework not only allows you to work with an array of XML technologies, but it also uses XML at many places itself. This chapter gave you an introduction to these areas.

You started with WPF applications, where the user interface is defined by XAML. You also displayed data from an XML document in a DataGrid of a WPF application.

ASP.NET uses XML heavily for server control markup and configuration. Then you learned about application configuration files. Specifically you learned to store and retrieve application configuration settings and database connection strings. The `web.config` file is an XML file that stores ASP.NET configuration information. You learned how to configure your web site to use forms authentication and session state. You also learned to configure custom error pages for dealing with unexpected errors in your web site.

Finally, you learned about XML comments—a feature that can assist documentation generation. You also used Sandcastle Help File Builder (SHFB) to convert the XML comments into HTML documentation.

CHAPTER 13



Working with LINQ to XML

Traditionally, software systems used different methods of accessing data from different datastores. For example, in order to access data from relational databases, flat files, and XML files, developers needed to learn and master different object models. These object models were often totally different from each other in terms of usage syntax and underlying philosophy. Beginning with the .NET Framework 3.5, Microsoft introduced Language Integrated Query (LINQ) technology that simplifies the hassle involved while consuming different sources of data. LINQ comes in three main flavors: LINQ to Objects, LINQ to ADO.NET, and LINQ to XML.

This chapter covers LINQ to XML features along with a brief primer on LINQ in general. Remember, however, that any detailed coverage of LINQ is beyond the scope of this book. This chapter restricts itself to the following topics:

- Brief introduction to LINQ expressions
- Capabilities of LINQ to XML
- When to use LINQ to XML
- Loading and saving XML documents using LINQ to XML
- Manipulating XML documents using LINQ to XML
- Validating XML documents using LINQ to XML
- Transforming XML documents using LINQ to XML

Overview of LINQ

Suppose that you are developing a complex application that deals with data stored in SQL Server, comma-separated files, in-memory collections, and XML files. You have been given a task to develop a set of classes that will take the data in and out of these datastores. As you might have guessed, you will probably end up with multiple data access strategies and object models, each specialized for a particular type of data source. Wouldn't it be nice if you could use just one unified way of accessing data for all your data sources? That's what LINQ is all about. LINQ provides a unified way of accessing data residing in in-memory collections, databases, and XML files. Figure 13-1 shows the overall architecture of LINQ.

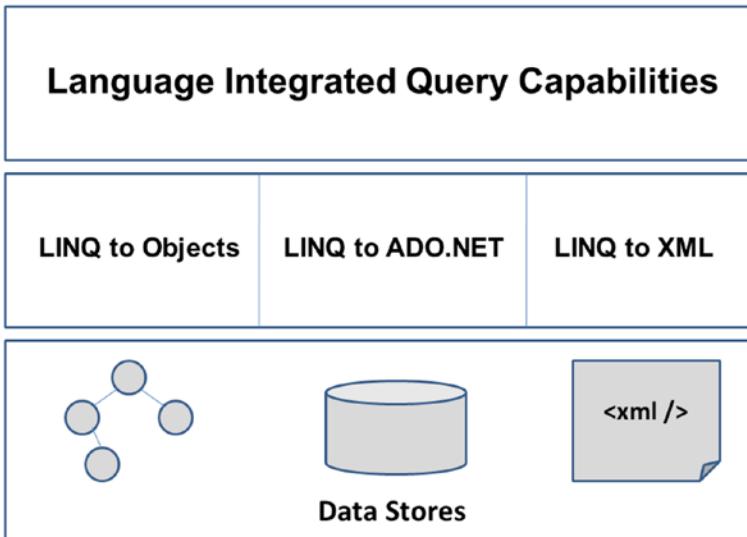


Figure 13-1. Architecture of LINQ

The bottom layer of the LINQ architecture consists of LINQ-enabled data sources. A LINQ-enabled data source is typically an object that implements the `IEnumerable<T>` or `IQueryable<T>` generic interfaces. You may wonder how relational databases and XML files will implement these interfaces; the LINQ to ADO.NET and LINQ to XML classes provide all the necessary infrastructure required to pull the data from such sources to a collection that implements the `IEnumerable<T>` or `IQueryable<T>` interfaces.

The .NET Framework provides what are known as *standard query operators* that work against any LINQ-enabled data source and provide facilities such as querying, filtering, sorting, and grouping the data. One can use the standard query operators directly on the LINQ data sources. However, to make life still easier, C# provides language keywords and constructs to perform LINQ tasks natively. That means querying the underlying datastore is now a feature integrated in the C# programming language itself. Using these features, you can write what are known as LINQ query expressions or LINQ queries.

Note Though you can use standard query operators to work with LINQ-enabled data sources, in this chapter I am going to use C# language keywords for writing the LINQ queries.

Working with LINQ Queries

To get a feel of how LINQ works at code level, let's develop a simple example. Through this example you will learn to group, sort, filter, and select data from generic collection. The example application is shown in Figure 13-2.

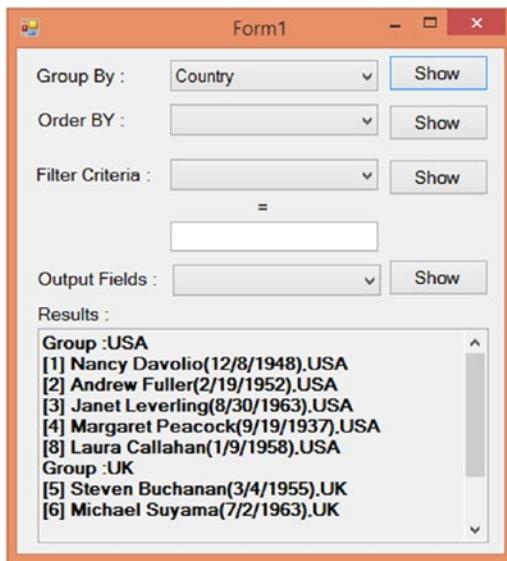


Figure 13-2. Basic LINQ operations

The application fills a generic list of Employee objects with data from the Employees table. The application user interface consists of a series of combo boxes that list columns of the Employee table (EmployeeID, FirstName, LastName, BirthDate, and Country). To group, sort, filter, and select data from the list, you can choose the desired field from the combo box and click the Show button. The results of the corresponding operation are shown in a read-only TextBox control.

Before you go into the details of LINQ queries, you first need to create the Employee class. Listing 13-1 shows the complete code of the Employee class.

Listing 13-1. The Employee Class

```
public class Employee
{
    public int EmployeeID { get; set; }
    public string FirstName { get; set; }
    public string LastName { get; set; }
    public DateTime BirthDate { get; set; }
    public string Country { get; set; }
    public static List<Employee> GetEmployees()
    {
        SqlConnection cnn = new SqlConnection(@"data source=.\sqlexpress;
            initial catalog=northwind;integrated security=true");
        cnn.Open();
        SqlCommand cmd = new SqlCommand(
            "SELECT employeeid,firstname,lastname,birthdate,country FROM employees");
        cmd.Connection = cnn;
        SqlDataReader reader = cmd.ExecuteReader();
        List<Employee> items = new List<Employee>();
        while (reader.Read())
        {
            Employee item = new Employee();
            item.EmployeeID = reader.GetInt32(0);
            item.FirstName = reader.GetString(1);
            item.LastName = reader.GetString(2);
            item.BirthDate = reader.GetDateTime(3);
            item.Country = reader.GetString(4);
            items.Add(item);
        }
        reader.Close();
        return items;
    }
}
```

```

        while (reader.Read())
    {
        Employee item = new Employee();
        item.EmployeeID = reader.GetInt32(0);
        item.FirstName = reader.GetString(1);
        item.LastName = reader.GetString(2);
        item.BirthDate = reader.GetDateTime(3);
        item.Country = reader.GetString(4);
        items.Add(item);
    }
    reader.Close();
    cnn.Close();
    return items;
}
}

```

The `Employee` class consists of five public properties, namely `EmployeeID`, `FirstName`, `LastName`, `BirthDate`, and `Country`. The static method `GetEmployees()` connects with the Northwind database and fetches all the records from the `Employees` table. The values are then filled in a list of `Employee` objects. Finally, the list is returned to the caller.

Once you create the `Employee` class, you can call its `GetEmployees()` method from the Load event of the form (see Listing 13-2).

Listing 13-2. Storing Employee Objects into a Generic List

```

List<Employee> employees = null;
private void Form1_Load(object sender, EventArgs e)
{
    employees = Employee.GetEmployees();
}

```

Notice that in Listing 13-2 the generic list is declared at class level because multiple functions need to access the data. The Load event handler of the form simply calls the `GetEmployees()` method and stores the returned data in the list.

Grouping Data Using LINQ

Listing 13-3 shows the Click event handler of the Show button that groups the data based on the selected field.

Listing 13-3. Grouping Data Using LINQ

```

private void button1_Click(object sender, EventArgs e)
{
    txtResults.Clear();
    if (comboBox1.SelectedItem.ToString() == "Country")
    {
        var result = from employee in employees
                    group employee by employee.Country;

```

```

foreach (var group in result)
{
    OutputResults("Group :" + group.Key);
    foreach (Employee emp in group)
    {
        OutputResults(emp);
    }
}
...
}

```

The code first decides which field is to be used for the purpose of grouping (we see the code that deals with the country field here). Then it forms a LINQ query expression that groups the items from the list based on that field. Notice the use of C# language extensions to LINQ in the form of the `var`, `from`, and `group` keywords. When you work with LINQ, the return type of the queries is often unknown at the time of writing the query. To indicate such an anonymous type, C# uses the `var` keyword. The LINQ query that follows indicates that you want to fetch all the items from the `employees` collection and want to group them by `Country` values. At runtime, this LINQ query returns a dictionary.

The outer `foreach` loop iterates through all the items of this dictionary. With each iteration, the key of the dictionary item is outputted in the text box using the `OutputResults()` helper method (discussed next). The inner `foreach` loop iterates through all the employees from a group and emits their details in the text box. Listing 13-3 shows the code only for the `Country` field, but the other fields will follow the same structure. The `OutputResults()` helper method has two overloads, as shown in Listing 13-4.

Listing 13-4. Outputting Results to a Text Box

```

private void OutputResults(Employee emp)
{
    txtResults.Text += "[" + emp.EmployeeID + "] ";
    txtResults.Text += emp.FirstName + " " + emp.LastName +
        "(" + emp.BirthDate.ToString("MM/dd/yyyy") + "), " +
        emp.Country + "\r\n";
}

private void OutputResults(string msg)
{
    txtResults.Text += msg + "\r\n";
}

```

The first overload of the `OutputResults()` helper method accepts an `Employee` object and appends its property values to the text box contents. The second overload simply accepts a string value and appends it to the text box contents.

Sorting Data Using LINQ

Now let's implement the sorting functionality. The sorting operation is done in the Click event handler of the second Show button. The part of the event handler is shown in Listing 13-5.

Listing 13-5. Sorting Data Using LINQ

```
private void button2_Click(object sender, EventArgs e)
{
    txtResults.Clear();
    if (comboBox2.SelectedItem.ToString() == "Country")
    {
        var result = from employee in employees
                    orderby employee.Country
                    select employee;
        foreach (var employee in result)
        {
            OutputResults(employee);
        }
    }
    ...
}
```

The `orderby` clause of a LINQ query sorts the results based on the indicated fields. The code in Listing 13-5 sorts the data on the basis of `Country` values. Notice the use of the `select` keyword that decides what to fetch. We will revisit the `select` keyword in later sections. The `foreach` loop then iterates the results and emits them in the text box.

Filtering Data Using LINQ

The employees list contains details about all the employees in the system. Often you need to work with a subset of the total data based on some criteria. The `where` clause of LINQ queries allows you to filter the data based on some condition. In our example, the Click event handler of the third Show button filters the employees list based on the criteria entered in the corresponding text box. A part of the relevant code is shown in Listing 13-6.

Listing 13-6. Filtering Data Using LINQ

```
private void button3_Click(object sender, EventArgs e)
{
    txtResults.Clear();
    if (comboBox3.SelectedItem.ToString() == "Country")
    {
        var result = from employee in employees
                    where employee.Country==textBox1.Text
                    select employee;
        foreach (var employee in result)
        {
            OutputResults(employee);
        }
    }
    ...
}
```

The code from Listing 13-6 filters the employees list for a specific country as supplied in the text box. Our example uses the `==` operator of C#. You can also use the `&&` (AND) and `||` (OR) operators to create more complex conditions. The results are then outputted to the text box as before.

Shaping Data Using LINQ

In all the LINQ queries so far, we fetched the entire Employee instance. What if we want only a part of the Employee instance or some computed data? That is where the `select` clause comes in handy. The `select` clause can be used to control the shape of the result (also known as the projection). In our examples, the output field's combo box governs which of the fields will be returned in the output. The actual shape of the output is decided by LINQ queries that go inside the `Click` event of the fourth Show button (see Listing 13-7).

Listing 13-7. Selecting Data Using LINQ

```
private void button4_Click(object sender, EventArgs e)
{
    txtResults.Clear();
    if(comboBox4.SelectedIndex==0)
    {
        var result = from employee in employees
                    select new
                    { employee.EmployeeID, employee.FirstName, employee.LastName };
        foreach (var emp in result)
        {
            OutputResults("[" + emp.EmployeeID + "] " +
            emp.FirstName + " " + emp.LastName);
        }
    }
    ...
}
```

The code first decides which of the fields of the `Employee` object are to be selected. It then constructs a new anonymous object that includes `EmployeeID`, `FirstName`, and `LastName` properties. The results are then outputted in the text box.

You can now run the application and test how these LINQ queries work.

Classic XML Technologies vs. LINQ to XML

Now that you have some idea about LINQ, let's focus on LINQ to XML. Before you delve into the actual coding, it would be beneficial to understand the key differences between classic XML technologies (XML DOM, XSLT, XSD, etc.) and LINQ to XML. The following sections summarize these key differences.

Working with XML Fragments

In classic XML technologies such as XML DOM, you essentially work with an XML document, so you access the XML data from top to bottom. This mechanism may not be ideal in each and every scenario, because while working with XML, your main focus is on elements and attributes. However, with a traditional DOM approach, you add an additional layer of complexity. LINQ for XML allows you to work with XML elements and attributes directly without bothering about the document node. This direct access allows you to work with XML fragments consisting of elements and attributes more easily.

Visual Construction of XML Trees

While working with XML DOM, you create various parts of an XML document (elements, attributes, text nodes, and so on) and then add them to the document. This style of creating XML documents does not give any visual clue about the document nesting. LINQ to XML provides what is known as *functional construction*, which allows you to create XML trees in a way that gives a visual clue about the nesting of the XML structure, as you'll see later in this chapter.

Ease in Namespace Handling

Dealing with XML namespaces and namespace prefixes is tedious in classic XML technologies. LINQ to XML takes away the complexity of dealing with namespace prefixes from developers by automatically doing the appropriate substitution at runtime.

Renaming XML Nodes

In DOM, you cannot directly rename a node. You need to create a new node and copy children of the older node to the new one. LINQ to XML simplifies this task by allowing you to rename nodes directly.

Static Methods to Load XML

While working with DOM, you must instantiate the `XmlDocument` class first and then load the XML document. LINQ to XML, however, allows you to load XML data via static methods, simplifying your code.

Whitespace Handling

When you read an XML file from disk, often it contains whitespace in the form of indentations. Such whitespace is not at all your focus as far as XML processing is concerned. However, while saving the data back, you may want to preserve the indentations. LINQ to XML simplifies whitespace handling for you. By default, when you save an XML document, only significant whitespace is saved. You can, of course, change this default behavior if you so desire.

XML Transformation

XSLT provides a rule-based, declarative approach for XML data transformation. However, many developers find XSLT difficult to master and spend a significant amount of time developing XSLT style sheets. LINQ to XML provides a programming model that most developers are familiar with. You can transform your XML document by using functional construction, gathering data from various sources, and assembling it in a new form. This can reduce development and maintenance costs. XSLT is still better when dealing with complex, document-centric scenarios.

When to Use LINQ to XML

In general, we can say that classic XML technologies are better if we want our applications to adhere to W3C standards and want to modify existing applications that already use the classic approaches. LINQ to XML can be a choice for new development where W3C compliance is not the concern and you want to code with the familiar syntax of C# without spending too much time mastering the XML family of technologies.

LINQ to XML Class Hierarchy

LINQ to XML provides an extensive collection of classes for a variety of purposes. These classes reside in the `System.Xml.Linq` namespace from the `System.Xml.Linq.dll` assembly. Figure 13-3 shows some of the most commonly used classes from this hierarchy.

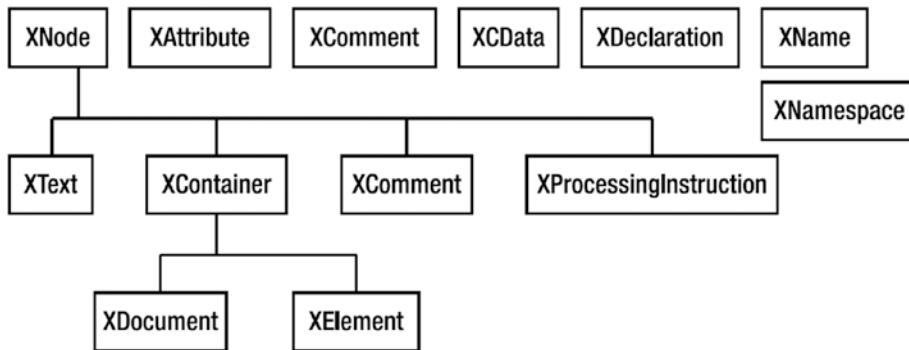


Figure 13-3. LINQ to XML class hierarchy

The `XNode` abstract class represents a node of an XML tree. The `XContainer`, `XText`, `XComment`, and `XProcessingInstruction` classes inherit from the `XNode` class. The `XContainer` class in turn acts as a base class for the `XDocument` and `XElement` classes. As you might have guessed, these classes represent a text node, comment, processing instruction, XML document, and element, respectively. The classes such as `XAttribute`, `XComment`, `XCData`, and `XDeclaration` are independent of the `XNode` hierarchy and represent attribute, comment, CDATA section, and XML declaration, respectively. The `XName` class represents the name of an element (`XElement`) or attribute (`XAttribute`). Similarly, the `XNamespace` class represents a namespace of an element or attribute.

Opening an Existing XML Document for Parsing

While working with classic XML DOM, you used the `XmlDocument` class to load an XML document. LINQ to XML offers two classes to load XML data: `XDocument` and `XElement`. In most situations, `XElement` is all you need to load XML files, streams, and fragments. However, in some rare cases, you may need to use `XDocument` instead. These special cases include the following:

- You want to add comments at the top level.
- You want to add processing instructions at the top level.
- You want to use a DTD for your XML document.

In any case, you can load XML data from a URI, a `TextReader`, an `XmlReader`, or even an XML string. To demonstrate the use of `XElement` in loading XML data, let's build an application like the one shown in Figure 13-4.

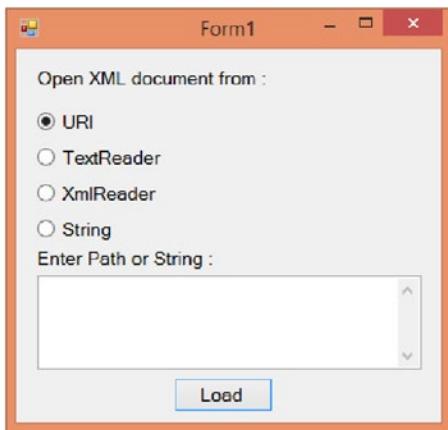


Figure 13-4. Application that loads XML data in XElement

The application consists of four radio buttons for selecting the place from which the XML data is to be loaded. The text box allows you to specify a URL where the XML file is located or raw XML markup. Clicking the Load button loads the data in an XElement and displays a message box with a success message. The Click event handler of the Load button is shown in Listing 13-8.

Listing 13-8. Loading XML Data Using XElement

```
private void button1_Click(object sender, EventArgs e)
{
    try
    {
        XElement root = null;
        if (radioButton1.Checked)
        {
            root = XElement.Load(textBox1.Text);
        }
        if (radioButton2.Checked)
        {
            StreamReader reader = File.OpenText(textBox1.Text);
            root = XElement.Load(reader);
        }
        if (radioButton3.Checked)
        {
            XmlReader reader = XmlReader.Create(textBox1.Text);
            root = XElement.Load(reader);
        }
        if (radioButton4.Checked)
        {
            root = XElement.Parse(textBox1.Text);
        }
        MessageBox.Show("XML Data Loaded Successfully!");
    }
}
```

```

    catch (Exception ex)
    {
        MessageBox.Show(ex.Message);
    }
}

```

The code consists of a series of if blocks for checking the selected radio button. The first three if blocks use the Load() method of the XElement class. Notice that Load() is a static method of the XElement class and accepts a URI, a TextReader, or an XmlReader as a source of XML data. If the XML data is in the form of a raw string, the Parse() method is used instead of Load(). The Load() and Parse() methods return an instance of the XElement class that can be used for further processing.

Note In order to compile the code from Listing 13-8, you must import the System.IO and System.Xml.Linq namespaces. This applies to most of the examples illustrated in this chapter.

To test the application, you can use the same Employees.xml file that we created in Chapter 2 (see Listing 2-2 for the complete XML markup).

Navigating Through an XML Tree

Under LINQ to XML, all the child nodes of an element can be accessed via the Nodes() method. The Nodes() method returns a sequence of IEnumerable<XNode> that can be iterated to access the individual nodes. If your interest is purely in elements, you can use the Elements() method that returns a sequence of IEnumerable< XElement >. The FirstNode and LastNode properties allow you to access the first and the last nodes, respectively. Similarly, the descendants can be accessed via the Descendants() method. To look at many of these methods in action, we will develop an application that populates a TreeView control with data from the Employees.xml file. The application user interface is shown in Figure 13-5.

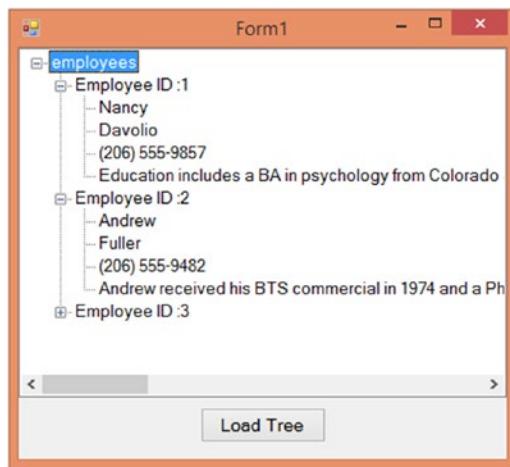


Figure 13-5. Navigating through an XML tree using LINQ to XML

The application consists of a TreeView control for displaying several `<employee>` elements. Each employee's TreeNode further displays information about that employee. The actual code to populate the tree view goes in the Click event handler of the Load Tree button (see Listing 13-9).

Listing 13-9. Loading the Tree with Employee Details

```
private void button1_Click(object sender, EventArgs e)
{
    XElement root = XElement.Load($"{Application.StartupPath}\\Employees.xml");
    TreeNode rootNode = new TreeNode(root.Name.LocalName);
    treeView1.Nodes.Add(rootNode);
    foreach(XElement employee in root.Elements())
    {
        TreeNode employeeNode = new TreeNode("Employee ID :" +
            employee.Attribute("employeeid").Value);
        rootNode.Nodes.Add(employeeNode);
        if (employee.HasElements)
        {
            foreach(XElement employeViewChild in employee.Descendants())
            {
                TreeNode childNode = new TreeNode(employeViewChild.Value);
                employeeNode.Nodes.Add(childNode);
            }
        }
    }
}
```

The code first loads the `Employees.xml` file into an instance of the `XElement` class. The `Name` property of the `XElement` class is of type `XName` and represents the name of the element. The `LocalName` property of the `XName` class returns the name of the underlying element without a namespace qualifier. This name is then used to add the root node of the `TreeView`.

Since we are interested only in the elements, the code uses the `Elements()` method to retrieve all the child elements of the `<employees>` element. The `employeeid` attribute of the `<employee>` element is accessed via the `Attribute()` method, which accepts the name of the attribute whose value is to be retrieved and returns an `XAttribute` instance representing that attribute. The `Value` property of the `XAttribute` class gives us the value of the attribute. A `TreeNode` for that employee is then added to the `TreeView`.

The `HasElements` Boolean property of the `XElement` class tells us whether an element has any child elements. If so, we iterate through all the descendants of the current `<employee>` element using its `Descendants()` method. In our example the `Descendants()` method will return four `XElements` for the `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>` elements, respectively. The `Value` property of the `XElement` class returns the inner content of the element, which is then displayed in a `TreeNode`.

Note In the preceding example, the structure of the XML document was known to us. In cases where the nesting of XML tags is not known at design time, you may use recursive code that traverses the entire nested hierarchy.

Looking for Specific Elements and Attributes

Searching XML data is a common requirement in many scenarios. LINQ to XML provides powerful ways to search your data. You can use all the features of LINQ to create your queries and look up the XML data. Most commonly we need to search:

- Elements matching a specific tag name
- Elements containing a specific value
- Attributes matching a specific value

In the sections that follow, we develop two applications: one allows you to search elements on the basis of their tag names, and the other allows you to grab one particular employee with a specific employee ID.

Retrieving Specific Elements Using the Descendants() Method

When you wish to retrieve a set of elements with a certain tag name, the `Descendants()` method can come in handy. In order to illustrate the use of the `Descendants()` method, we develop an application like the one shown in Figure 13-6.

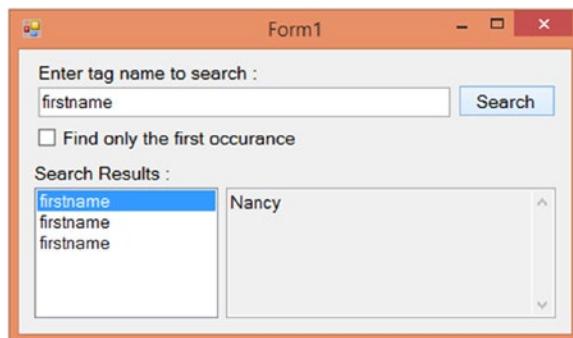


Figure 13-6. Application for searching elements by tag name

The application consists of a text box for specifying the tag name to search for. Upon clicking the Search button, the results will be displayed in a list box. Selecting a particular tag name from the list box will show its value in another read-only text box. The check box titled “Find Only the First Occurrence” determines whether to find all instances of the tag name or end the search after the first match is found.

The code that makes the application work is shown in Listing 13-10.

Listing 13-10. Using the `Descendants()` Method to Search Specific Elements

```
XElement root = null;
 XElement[] datasource = null;

private void Form1_Load(object sender, EventArgs e)
{
    root = XElement.Load($"{Application.StartupPath}\\employees.xml");
}
```

```

private void button1_Click(object sender, EventArgs e)
{
    textBox2.Text = "";
var subset = from item in root.Descendants(textBox1.Text)
              select item;

    if (!checkBox1.Checked)
    {
        datasource = subset.ToArray();
    }
    else
    {
        if (subset.Count() > 0)
        {
            datasource = new XElement[1];
            datasource[0] = subset.First();
        }
    }
    listBox1.DataSource = datasource;
    listBox1.DisplayMember = "Name";
}
private void listBox1_SelectedIndexChanged(object sender, EventArgs e)
{
    textBox2.Text= datasource[listBox1.SelectedIndex].Value;
}

```

The code declares two class-level variables: `root` and `datasource`. The `root` variable is of type `XElement` and holds a pointer to the root node of `Employees.xml`. The `datasource` variable is an array of type `XElement` and is used for data binding. The `Employees.xml` file is loaded into the `root` variable in the `Load` event of the form.

The main job of searching a tag name happens in the `Click` event handler of the Search button. Notice the LINQ query shown in bold. It uses the `Descendants()` method of the `XElement` class. The `Descendants()` method has two overloads: one that doesn't take any parameters and one that takes an element name as the parameter. The former overload returns all the descendant elements of the current node, whereas the latter overload returns all the descendant elements that match the specified tag name. If the check box is unchecked (i.e., we want to display all occurrences of the specified tag), then we convert the result into an array of `XElement` objects using the `ToArray()` method. Otherwise, we create an array of `XElements` manually and store the first occurrence of the element in it. Notice the use of the `First()` method to retrieve just the first instance of the element. The `datasource` variable is then bound with the list box.

In order to display the actual value of the element, the code handles the `SelectedIndexChanged` event of the list box. Inside it simply retrieves the selected `XElement` from the `datasource` array and displays its `Value` property in the text box.

To test the application, run it from Visual Studio. Type `firstname` in the search text box and click the Search button. The application should list three occurrences of the `<firstname>` tag in the list box. Click any of the instances, and you should see its value displayed in the other text box.

Searching on the Basis of Attribute Values

XML data often needs to be searched on the basis of attribute values and not just tag names. The `Attributes()` and `Attribute()` methods help you to do just that. To demonstrate the use of these methods, we will develop an application like the one shown in Figure 13-7.

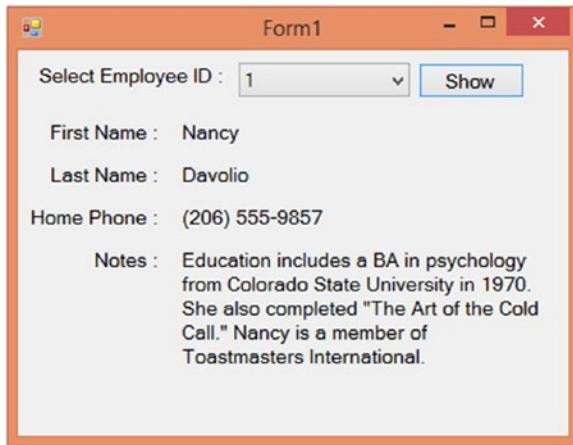


Figure 13-7. Application for searching attribute values

The application consists of a combo box that displays a list of employee IDs. Recollect that the Employees.xml file stores employee IDs in the employeeid attribute of the `<employee>` element. Upon selecting a specific employee ID and clicking the Show button, the details of that employee (first name, last name, home phone, and notes) are displayed. The code that does the searching is shown in Listing 13-11.

Listing 13-11. Searching Attribute Values

```
private void Form1_Load(object sender, EventArgs e)
{
    root = XElement.Load($"{Application.StartupPath}\\employees.xml");
    var result = from item in root.Elements("employee")
                 where item.Attributes("employeeid").Count() > 0
                 select item.Attribute("employeeid").Value;
    foreach (var obj in result)
    {
        comboBox1.Items.Add(obj);
    }
}

private void button1_Click(object sender, EventArgs e)
{
    var result = from item in root.Elements("employee")
                 where item.Attribute("employeeid").
                     Value == comboBox1.SelectedItem.ToString()
                 select item;
    foreach (var obj in result)
    {
        label6.Text = obj.Element("firstname").Value;
        label7.Text = obj.Element("lastname").Value;
        label8.Text = obj.Element("homephone").Value;
        label9.Text = obj.Element("notes").Value;
    }
}
```

The code loads the `Employees.xml` file into an instance of `XElement` in the Load event of the form. It then calls the `Elements()` method on the root element by supplying the tag name as `employee`. This way, only the elements with the `employee` tag name are returned. The `where` clause then checks if these elements contain the `employeeid` attribute and, if so, it returns the value of the `employeeid` attribute.

The `Attributes()` method has two overloads: one takes no parameters and the other accepts the attribute name as the parameter. The former overload returns all the attributes (in the form of an `XAttribute` collection) of an element, whereas the latter one returns only the attributes with the specified name. The `Attribute()` method accepts the name of an attribute to retrieve and returns an `XAttribute` instance associated with it. Notice that the query selects just the attribute value. The `foreach` loop then iterates through the results and populates the employee IDs into the combo box.

In the Click event handler of the Show button, the code fetches an element whose `employeeid` attribute matches the value selected in the combo box. The `Value` property of the `XAttribute` class represents the value of an attribute. The results are then displayed in the Label controls.

Modifying XML Data

LINQ to XML provides easy ways for adding, removing, and changing the content of an XML tree. These ways can be best seen with an example. Let's create an application like the one shown in Figure 13-8 that represents a data entry screen for the `Employees.xml` file.

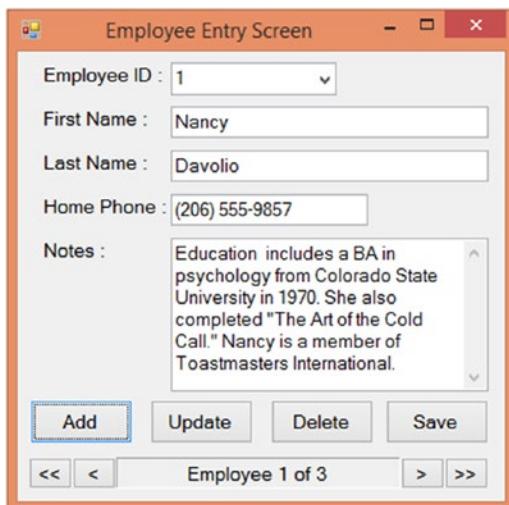


Figure 13-8. Data entry screen for the `Employees.xml` file

The application displays `<employee>` elements from the `Employees.xml` file. You can navigate among various employees using the VCR controls provided at the bottom. You can also jump to an employee with a specific employee ID using the combo box. The Add, Update, and Delete buttons add, change, or remove an `<employee>` element from the underlying XML tree, respectively. The Save button saves the modified XML tree back to the `Employees.xml` file.

Loading the XML Document

When the application starts, it loads the `Employees.xml` file into an instance of the `XElement` class. This is done in the Load event of the form (see Listing 13-12).

Listing 13-12. Loading an XML Document

```
XElement doc = null;

private void Form1_Load(object sender, EventArgs e)
{
    doc=XElement.Load($"{Application.StartupPath}\\Employees.xml");
    var result=from item in doc.Descendants("employee")
               select item.Attribute("employeeid").Value;
    foreach (var obj in result)
    {
        comboBox1.Items.Add(obj);
    }
    FillControls();
}
```

The code declares a variable of type `XElement` at form level. In the Load event, it loads `Employees.xml` into it. The descendant elements of the root node (i.e., all the `<employee>` elements) are retrieved using the `Descendants()` method, and their attributes are added to the combo box. The `FillControls()` method (discussed later) simply fetches the `<employee>` element matching the currently selected employee ID and displays its details (first name, last name, home phone, and notes) in the appropriate text boxes.

Navigating Between Various Nodes

The VCR arrangement at the bottom of the screen allows you to navigate among various `<employee>` elements. The Click event handlers of the next, previous, first, and last buttons (see Listing 13-13) essentially adjust the selected index of the combo box and call the `FillControls()` helper method to show the details of the selected employee.

Listing 13-13. Navigating Among Employee Elements

```
private void button4_Click(object sender, EventArgs e)
{
    comboBox1.SelectedIndex = 0;
    FillControls();
}

private void button5_Click(object sender, EventArgs e)
{
    if (comboBox1.SelectedIndex > 0)
    {
        comboBox1.SelectedIndex = comboBox1.SelectedIndex - 1;
    }
    FillControls();
}
```

```

private void button6_Click(object sender, EventArgs e)
{
    if (comboBox1.SelectedIndex < comboBox1.Items.Count - 1)
    {
        comboBox1.SelectedIndex = comboBox1.SelectedIndex + 1;
    }
    FillControls();
}

private void button7_Click(object sender, EventArgs e)
{
    comboBox1.SelectedIndex = comboBox1.Items.Count - 1;
    FillControls();
}

```

Adding New Content

In order to add a new employee, we need to specify employee ID, first name, last name, and notes in the respective controls and click the Add button. Inside the Click event of the Add button, we need to create new XElement instances that represent <employee>, <firstname>, <lastname>, <homephone>, and <notes> elements. Listing 13-14 shows how this is done.

Listing 13-14. Adding a New Employee Element

```

private void button1_Click(object sender, EventArgs e)
{
    XElement employee = new XElement("employee",
        new XElement("firstname", textBox1.Text),
        new XElement("lastname", textBox2.Text),
        new XElement("homephone", textBox3.Text),
        new XElement("notes",
            new XCData(textBox4.Text)));
    employee.SetAttributeValue("employeeid", comboBox1.Text);
    doc.Add(employee);
    comboBox1.Items.Add(comboBox1.Text);
    FillControls();
}

```

Notice the markup in Listing 13-14 carefully. The code creates a new instance of the XElement class using functional construction. The code written using functional construction gives a visual indication about the nesting of the XML tree. After looking at our code, you can easily identify that <firstname>, <lastname>, <homephone>, and <notes> are the child elements of the <employee> element. The constructor of the XElement class accepts a parameter array of content elements. The code supplies four new instances of the XElement class as the second parameter of the main XElement instance. Since the element representing notes can contain CDATA, its value is passed as an instance of the XCData class.

The employeeid attribute of the newly created <employee> element is assigned via the SetAttributeValue() method. The SetAttributeValue() method accepts an attribute name and its value as the parameter. If that attribute already exists, the method changes the attribute's value; otherwise, it adds the attribute.

The <employee> element is then added to the root element using the Add() method of the XElement class. The Add() method adds the supplied content as the child element of the current element.

Modifying Existing Content

Any changes to the values of the <firstname>, <lastname>, <homophone>, and <notes> elements are saved in the XML tree in the Click event of the Update button (see Listing 13-15).

Listing 13-15. Modifying an Existing Element

```
private void button2_Click(object sender, EventArgs e)
{
    string employeeid = comboBox1.SelectedItem.ToString();
    var employees = from item in doc.Descendants("employee")
                    where item.Attribute("employeeid").Value == employeeid
                    select item;
    foreach (var employee in employees)
    {
        employee.SetElementValue("firstname", textBox1.Text);
        employee.SetElementValue("lastname", textBox2.Text);
        employee.SetElementValue("homophone", textBox3.Text);
        employee.SetElementValue("notes", textBox4.Text);
    }
}
```

The code first selects only the <employee> element whose employeeid attribute matches the one selected in the combo box. It then calls the SetElementValue() method of the XElement class on the selected employee. The SetElementValue() method takes two parameters: the name of the element whose value is to be set and the new value of the element. If the element doesn't exist, it is added as a child element of the current element.

Deleting Existing Content

In order to delete an employee, we need to find it from the available <employee> elements and remove it from the XML tree. The Click event handler of the Delete button does this task (see Listing 13-16).

Listing 13-16. Deleting an Existing Element

```
private void button3_Click(object sender, EventArgs e)
{
    string employeeid = comboBox1.SelectedItem.ToString();
    var employees = from item in doc.Descendants("employee")
                    where item.Attribute("employeeid").Value == employeeid
                    select item;
    foreach (var employee in employees)
    {
        employee.Remove();
        break;
    }
    comboBox1.Items.Remove(employeeid);
    FillControls();
}
```

The code first finds the employee that is to be deleted. It then calls the Remove() method on the employee XElement. The Remove() method removes the current element from the tree.

Saving the Modified XML Tree to a File

The modified XML tree can be saved back to the disk using the `Save()` method of the `XElement` class. Listing 13-17 shows the relevant code.

Listing 13-17. Saving an XML Tree to a File

```
private void button8_Click(object sender, EventArgs e)
{
    doc.Save($"{Application.StartupPath}\\Employees.xml");
}
```

The `Save()` method simply accepts the path of the file where the XML tree is to be saved. In addition to saving an XML tree to a file, you can also use the `Save()` method to serialize an XML tree to `XmlWriter` or `TextWriter` objects.

Displaying Employee Details

In the preceding code, we use the `FillControls()` helper method to display details of the current employee. This method is shown in Listing 13-18.

Listing 13-18. Displaying the Current Employee's Details

```
private void FillControls()
{
    if (comboBox1.SelectedIndex == -1)
    {
        comboBox1.SelectedIndex = 0;
    }
    string employeeid = comboBox1.SelectedItem.ToString();
    var employees = from item in doc.Elements()
                    where item.Attribute("employeeid").Value == employeeid
                    select item;
    foreach (var employee in employees)
    {
        textBox1.Text = employee.Element("firstname").Value;
        textBox2.Text = employee.Element("lastname").Value;
        textBox3.Text = employee.Element("homephone").Value;
        textBox4.Text = employee.Element("notes").Value;
    }
    label6.Text = $"Employee {(comboBox1.SelectedIndex + 1)} of {comboBox1.Items.Count}";
}
```

The `FillControls()` helper method simply retrieves the `<employee>` element whose `employeeid` attribute is selected in the combo box. It then fills the text boxes with `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>` element values. The `Element()` method accepts the name of an XML element and returns the first occurrence of that element as an `XElement` instance.

Finally, the status label of the VCR display is updated to reflect the current employee position.

Note In addition to the `SetElementValue()` and `SetAttributeValue()` methods, you can also use the `Value` property of the `XElement` and `XAttribute` classes to set the value of an existing element or attribute, respectively. Similarly, in addition to the `Add()` method, you can use the `AddBeforeSelf()` and `AddAfterSelf()` methods to add content before and after the current element, respectively.

Events of the XElement Class

Whenever any of the elements is added, removed, or renamed, the `XElement` class raises `Changing` and `Changed` events. The `Changing` event is raised just before the actual change occurs, whereas the `Changed` event is raised after the change is made. These events give you a chance to perform pre-operations and post-operations related to the change.

To illustrate the use of these events, let's modify the preceding application to add support for `Changing` and `Changed` events.

Modify the `Load` event of the form to reflect the changes shown in Listing 13-19.

Listing 13-19. Wiring Changing and Changed Event Handlers

```
private void Form1_Load(object sender, EventArgs e)
{
    doc=XElement.Load($"{Application.StartupPath}\\\employees.xml");

doc.Changing += new EventHandler<XObjectChangeEventArgs>(doc_Changing);
doc.Changed += new EventHandler<XObjectChangeEventArgs>(doc_Changed);

    var result=from item in doc.Descendants("employee")
              select item.Attribute("employeeid").Value;
    foreach (var obj in result)
    {
        comboBox1.Items.Add(obj);
    }
    FillControls();
}
```

Notice the code marked in bold. The code wires the event handlers for `Changing` and `Changed` events. Both of these events receive an event argument parameter of type `XObjectChangeEventArgs`. The event handler for the `doc_Changed` event handler is shown in Listing 13-20.

Listing 13-20. Handling a Changed Event of XElement

```
void doc_Changed(object sender, XObjectChangeEventArgs e)
{
    string msg = "";
    switch (e.ObjectChange)
    {
        case XObjectChange.Add:
            msg = "A new element has been added";
            break;
```

```

case XObjectChange.Remove:
    msg = "An element has been removed";
    break;
case XObjectChange.Name:
    msg = "An element has been renamed";
    break;
case XObjectChange.Value:
    msg = "Value has been changed";
    break;
}
MessageBox.Show(msg);
}

```

The `XObjectEventArgs` class simply provides a hint about the cause of the event. The possible causes are adding an element (Add), removing an element (Remove), renaming an element (Name), and changing the value of an element (Value). Depending on the cause, the code may simply display a message to the user.

In order to test these events, run the application, change employee details, and click the Update button. You should see a series of message boxes informing you about the changes. Figure 13-9 shows a sample run of the application.

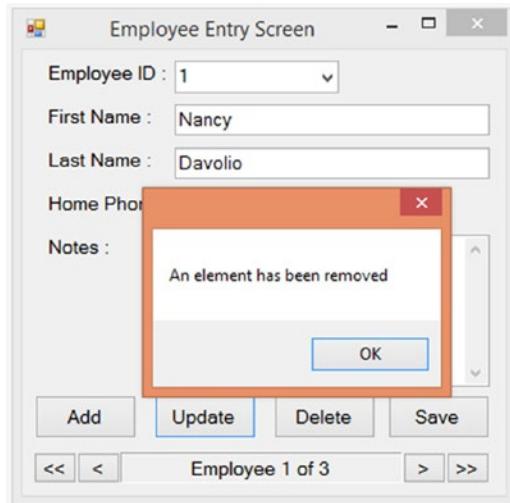


Figure 13-9. Changed event raised after modifying an employee's information

Dealing with Whitespace

The behavior of whitespace can be controlled when you call the `Load()`, `Parse()`, and `Save()` methods on `XElement` or `XDocument`. The `Load()` and `Parse()` methods provide overloads that accept a parameter of type `LoadOptions`. The `LoadOptions` enumeration allows you to specify whether or not to preserve whitespace while loading the XML tree. Similarly, the `Save()` method provides an overload that accepts a parameter of type `SaveOptions`. The `SaveOptions` enumeration allows you to specify whether spaces should be preserved while serializing the XML tree.

To illustrate the use of `LoadOptions` and `SaveOptions` enumerations, let's develop an application like the one shown in Figure 13-10.

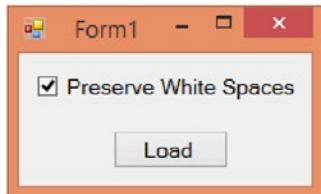


Figure 13-10. Application to demonstrate whitespace handling

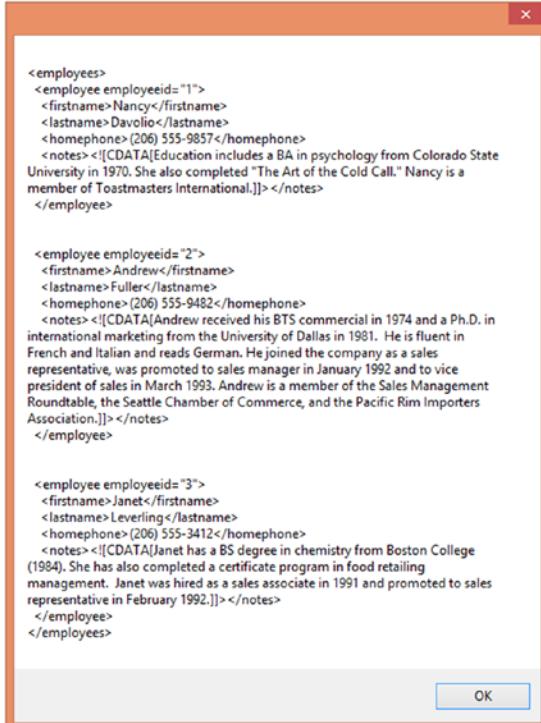
The application loads the `Employees.xml` file when you click the Load button. The Preserve White Spaces check box indicates whether we want to preserve whitespace during document loading and saving. The Click event handler of the Load button is shown in Listing 13-21.

Listing 13-21. Using `LoadOptions` and `SaveOptions` Enumerations

```
private void button1_Click(object sender, EventArgs e)
{
    XElement root = null;
    string path= $"{Application.StartupPath}\\employees.xml";
    if (!checkBox1.Checked)
    {
        root=XElement.Load(path, LoadOptions.None);
        MessageBox.Show(root.ToString());
        root.Save(path, SaveOptions.None);
    }
    else
    {
        root=XElement.Load(path, LoadOptions.PreserveWhitespace);
        MessageBox.Show(root.ToString());
        root.Save(path, SaveOptions.DisableFormatting);
    }
}
```

The code loads the `Employees.xml` file into an instance of the `XElement` class. Depending on the check box state, it decides the appropriate `LoadOptions` value. The value of `None` indicates that we do not intend to preserve insignificant whitespace, whereas the value of `PreserveWhitespace` indicates that we wish to preserve whitespace. Similarly, while saving the document back to the disk, the `SaveOptions` value governs the whitespace behavior. The value of `None` indicates that the document will be indented, and insignificant whitespace will not be preserved, whereas the value of `DisableFormatting` indicates that we do not want to indent the document, and whitespace will be preserved as they are. The XML content loaded in the `XElement` are displayed in a message box using the `ToString()` method of the `XElement` class.

Try running the application with the check box unchecked (see Figure 13-11) and checked (see Figure 13-12). Notice that the message box in Figure 13-12 has preserved the whitespace.

**Figure 13-11.** Output with `LoadOptions.None`**Figure 13-12.** Output with `LoadOptions.PreserveWhitespace`

Note Remember that just like XML DOM, the parsing process will be affected when you preserve whitespace (refer to the discussion from Chapter 2 in the “Dealing with Whitespace” section). However, since LINQ to XML allows you to query the XML tree in flexible ways, whitespace will not create any problem as long as you are not relying on the count of elements in your logic.

Dealing with Namespaces

At times the XML data that you are processing might be using XML namespaces. In such cases you may want to find out information about the namespace the XML data is using. The `Name` property of the `XElement` class provides a convenient place to obtain all the information about namespaces.

To illustrate the use of the `Name` property, we will create an application as shown in Figure 13-13.

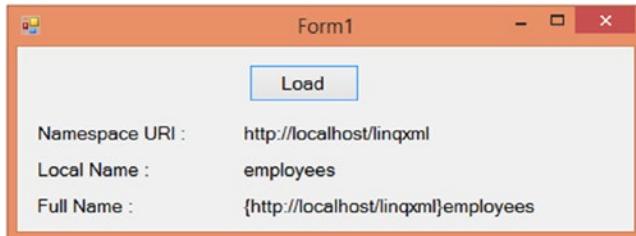


Figure 13-13. Obtaining namespace information

The application consists of a Load button that loads the `Employees.xml` file. The namespace details are then displayed in the Label controls. In this example, we use the `Employees.xml` file from Listing 2-21 in Chapter 2. A part of the complete file is provided in Listing 13-22.

Listing 13-22. Employees.xml with a Namespace

```
<emp:employees xmlns:emp=" http://localhost/linqxml">
  <emp:employee employeeid="1">
    <emp:firstname>Nancy</emp:firstname>
    <emp:lastname>Davolio</emp:lastname>
    <emp:homephone>(206) 555-9857</emp:homephone>
...

```

Various markup tags of this listing are namespace qualified. The Click event handler of the Load button is shown in Listing 13-23.

Listing 13-23. Using the `Name` Property to Obtain Namespace Information

```
private void button1_Click(object sender, EventArgs e)
{
  XElement root = XElement.Load($"{Application.StartupPath}\\employees.xml");
  label4.Text = root.Name.NamespaceName;
  label5.Text = root.Name.LocalName;
  label6.Text = root.Name.ToString();
}
```

The code loads the `Employees.xml` file in an instance of the `XElement` class. The `Name` property of `XElement` is of type `XName`. The `Namespace` property of `XName` class gives the complete namespace name. The `LocalName` gives the name of the elements without the namespace qualifier, for example, `employee`, whereas calling the `Tostring()` method returns the element name along with the namespace qualifier. Notice how the namespace-qualified element name is shown in Figure 13-13. The namespace is enclosed in braces ({ and }) followed by the local name of the element.

Specifying Namespaces While Constructing Elements

When you create an XML tree programmatically, you need to specify namespace information associated with it using the `XNamespace` class. To illustrate how this is done, we will develop an application like the one shown in Figure 13-14.

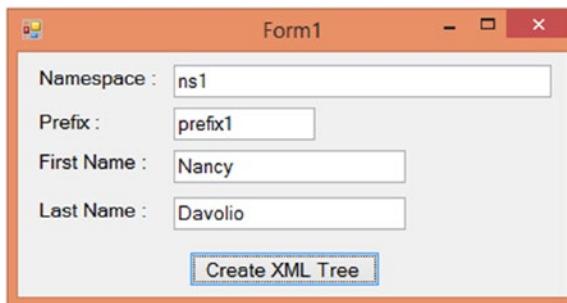


Figure 13-14. Application that creates an XML tree with a namespace

The application consists of four text boxes for entering a namespace name, a namespace prefix (if any), a first name, and a last name. Clicking the Create XML Tree button creates `XElement` and `XAttribute` instances as required and displays the resultant XML tree in a message box. The `Click` event handler of the button is shown in Listing 13-24.

Listing 13-24. Using `XNamespace` to Specify Namespace Information

```
private void button1_Click(object sender, EventArgs e)
{
    XNamespace ns = textBox1.Text;
    XElement root = new XElement(ns + "employee",
        new XElement(ns + "firstname", textBox3.Text),
        new XElement(ns + "lastname", textBox4.Text));
    if (textBox2.Text == "")
    {
        root.SetAttributeValue("xmlns", ns);
    }
    else
    {
        root.SetAttributeValue(XNamespace.Xmlns + textBox2.Text, ns);
    }
    MessageBox.Show(root.ToString());
}
```

The code creates an instance of the `XNamespace` class and sets the namespace name as indicated in the text box. Notice that the `=` operator is overloaded, and hence you can assign a string value directly to its instance. The `<employee>` element is then created. While specifying an element name, the code appends the element name to the namespace. If a namespace prefix is not specified, an attribute with the name `xmlns` is added to the root element. This way, the code defines a default namespace for the XML tree. If a namespace prefix is specified, that prefix is appended to the `xmlns` URI (see <http://www.w3.org/2000/xmlns/> for more information on `xmlns`). Notice the use of the `XNamespace.Xmlns` property, which returns an `XNamespace` object corresponding to the `xmlns` URI. Finally, the resultant XML tree is shown using a message box. Figure 13-15 shows a sample generation of an XML tree.

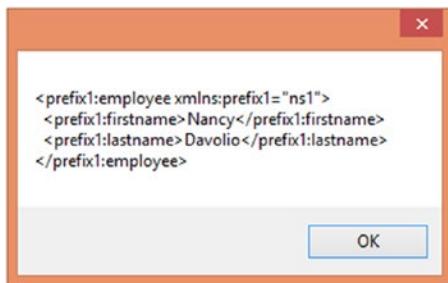


Figure 13-15. XML tree with namespace information

Validating XML Documents

XML documents are often validated against XML Schemas to ensure correctness of data. In Chapter 5, you learned validation techniques using `XmlDocument`, `XmlReader`, and `XPathNavigator`. Now it's time to see how LINQ to XML can be used to validate XML documents against XML Schemas. The `XDocument` as well as `XElement` classes provide an extension method named `Validate()` that does the job of validating the XML data against the XML Schema. Remember that, in order to access the `Validate()` extension method, you must import the `System.Xml.Schema` namespace in your code.

Note Extension methods enable you to add methods to an existing class without inheriting or modifying the original class. They are a special kind of static methods that are called as if they were instance methods on the extended class.

To illustrate the use of the `Validate()` method, we will create an application like the one shown in Figure 13-16.

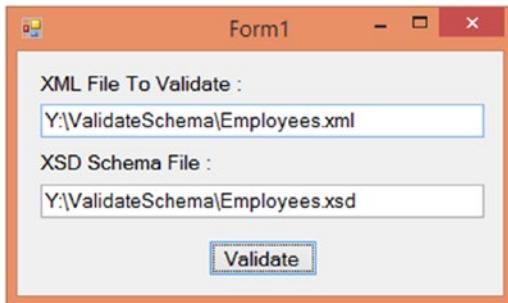


Figure 13-16. Application that validates XDocument against an XML Schema

The application consists of two text boxes and one button. The text boxes accept a path to the XML document that is to be validated and a path to the XML Schema file. Clicking the Validate button loads the XML document in an `XDocument` instance and validates the document against the supplied schema. Errors during validation (if any) are reported to the user. In this example, we will use the `Employees.xsd` schema file that we developed in Chapter 5 to validate the `Employees.xml` file. Just to give you a quick recap of the structure of the XSD Schema file, Listing 13-25 shows a part of it.

Listing 13-25. Partial Markup from Employees.xsd

```
<?xml version="1.0" encoding="utf-8"?>
<xss:schema attributeFormDefault="unqualified"
elementFormDefault="qualified"
xmlns:xss="http://www.w3.org/2001/XMLSchema">
  <xss:element name="employees">
    <xss:complexType>
      <xss:sequence>
        <xss:element name="employee" type="EmployeeType" minOccurs="0"
          maxOccurs="unbounded" />
      </xss:sequence>
    </xss:complexType>
  </xss:element>
  <xss:complexType name="EmployeeType">
    <xss:all>
      <xss:element name="firstname" type="NameSimpleType" />
      <xss:element name="notes" type="NotesSimpleType" />
      <xss:element name="lastname" type="NameSimpleType" />
      <xss:element name="homephone" type="PhoneSimpleType" />
    </xss:all>
  ...

```

The Click event handler of the Validate button is shown in Listing 13-26.

Listing 13-26. Validating Against the XSD Schema

```
private void button1_Click(object sender, EventArgs e)
{
  XDocument doc = XDocument.Load(textBox1.Text);
  XmlSchemaSet schema=new XmlSchemaSet();
```

```

schema.Add(null, textBox2.Text);
ValidationEventHandler handler = new ValidationEventHandler(MyHandler);
doc.Validate(schema, handler);
}

public void MyHandler(object sender, ValidationEventArgs e)
{
    MessageBox.Show(e.Message);
}

```

The code loads the source XML document in an instance of the `XDocument` class. It then creates an `XmlSchemaSet` and adds the specified XML Schema to it using the `Add()` method. The `Validate()` extension method of the `XDocument` class accepts two parameters: `XmlSchemaSet` and an event handler that gets called if validation fails. The event handler is of type `ValidationEventHandler`. The `MyHandler()` method acts as the event handler in our example. The validation is triggered by calling the `Validate()` method. If there are any validation errors, the `MyHandler()` event handler gets invoked. The `MyHandler()` event handler receives a parameter of type `ValidationEventArgs`. The `Message` property of the `ValidationEventArgs` class provides information about the validation errors.

In order to test the code, remove the `employeeid` attribute from the first `<employee>` element of the `Employees.xml` file and run the application. Figure 13-17 shows a validation error message after a sample run.

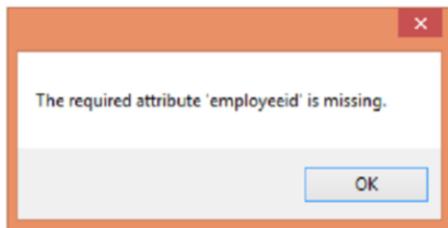


Figure 13-17. A validation error

Transforming XML Trees

In Chapter 6, we discussed how to transform XML data using XSLT style sheets. Though that approach still remains valid, LINQ to XML provides a new handy way of transforming XML data. Using this new approach, you can transform XML from one shape to another without knowing anything about XSLT.

Note The *shape* of an XML document refers to its element names, attribute names, and nesting of its hierarchy.

There are two common scenarios in transforming XML:

- You may want to transform an XML tree into an HTML tree. Similarly, you may want to transform an XML tree into another XML tree with an altogether different shape.
- You may want to project source XML code into an altogether different type.

In any case, LINQ to XML, along with its functional construction feature, provides an easy way to accomplish your task.

Changing the Shape of an XML Tree

Your transformation may call for a change in the shape of source XML tree. This is a common scenario when you want to transform XML into HTML for the purpose of displaying in the browser. This might also be needed while transferring XML data from one software system to another when the other system expects a different XML shape. To demonstrate how functional construction in LINQ to XML makes it easy to accomplish such changes in the shape, we will create an application like the one shown in Figure 13-18.

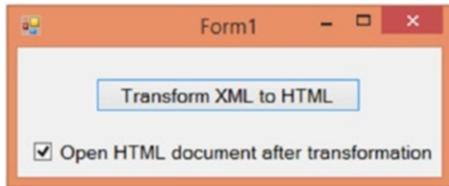


Figure 13-18. Application that transforms XML into HTML

The application consists of a button titled Transform XML to HTML and a check box. When you click the button, the XML data from Employees.xml is transformed into an HTML table and saved as Employees.htm. If the check box is checked, the Employees.htm file is displayed in the browser.

The code that does the job of transforming the data is shown in Listing 13-27.

Listing 13-27. Transforming an XML Tree Using Functional Construction

```
private void button1_Click(object sender, EventArgs e)
{
    XElement root = XElement.Load($"{Application.StartupPath}\\employees.xml");
    XElement html =
        new XElement("html",
            new XElement("body",
                new XElement("table",
                    new XAttribute("border", 1),
                    new XElement("th", "Employee ID"),
                    new XElement("th", "First Name"),
                    new XElement("th", "Last Name"),
                    new XElement("th", "Home Phone"),
                    new XElement("th", "Notes"),
                    from item in root.Descendants("employee")
                    select new XElement("tr",
                        new XElement("td",
                            item.Attribute("employeeid").Value),
                        new XElement("td",
                            item.Element("firstname").Value),
                        new XElement("td",
                            item.Element("lastname").Value),
                        new XElement("td",
                            item.Element("homephone").Value),
                        new XElement("td",
                            item.Element("notes").Value)))));

    html.Save($"{Application.StartupPath}\\employees.htm");
```

```

if (checkBox1.Checked)
{
    Process.Start($"{Application.StartupPath}\\\employees.htm");
}
else
{
    MessageBox.Show($"Output saved as {Application.StartupPath}\\\employees.htm");
}
}

```

The code loads the `Employees.xml` file into an instance of the `XElement` class. It then creates another `XElement` named `html` using functional construction. Notice how the XML data is selected from descendant `<employee>` elements into the new `XElement` objects. Effectively, in just one statement, we are able to transform the source XML tree into HTML.

The new `XElement` formed after transformation is saved to the disk as the `Employees.htm` file. If the check box is checked, the code opens the `Employees.htm` file in the browser; otherwise, a success message box is displayed. Figure 13-19 shows the `Employees.htm` file generated as a result of a sample run of the application.

The screenshot shows a Microsoft Edge browser window with the title bar "file:///Y:/Cha.../employees.htm". The main content area displays a table with five columns: Employee ID, First Name, Last Name, Home Phone, and Notes. The first row contains data for Nancy Davolio, and the second row contains data for Andrew Fuller. The "Notes" column for each row contains a detailed biography of the respective employee.

Employee ID	First Name	Last Name	Home Phone	Notes
1	Nancy	Davolio	(206) 555-9857	Education includes a BA in psychology from Colorado State University in 1970. She also completed "The Art of the Cold Call." Nancy is a member of Toastmasters International.
2	Andrew	Fuller	(206) 555-9482	Andrew received his BTS commercial in 1974 and a Ph.D. in international marketing from the University of Dallas in 1981. He is fluent in French and Italian and reads German. He joined the company as a sales representative, was promoted to sales manager in January 1992 and to vice president of sales in March 1993. Andrew is a member of the Sales Management Roundtable, the Seattle Chamber of Commerce, and the Pacific Rim Importers Association.

Figure 13-19. Resultant HTML markup

Note In addition to using functional construction, you can also create individual `XElements` and `XAttributes` and then create the required nesting. However, functional construction makes your code tidy and easy to read. If your XML data is generated as a result of some complex processing or logic, then you may need to create various elements and attributes as stand-alone entities and then associate them with each other. This process is very similar to the approach taken by XML DOM.

Projecting a New Type

Projection is the process by which source data is filtered, has its shape changed, or even has its type changed. For example, suppose that you want to load data from `Employees.xml` into a new collection of `Employee` objects such that each `Employee` object has the values filled from the `<firstname>`, `<lastname>`, `<homephone>`, and `<notes>` elements of the source XML.

In order to illustrate how projection works, we will create an application like the one shown in Figure 13-20.

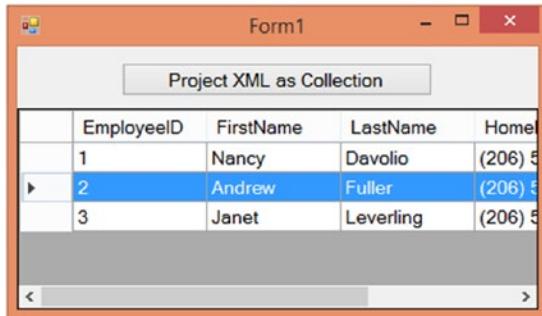


Figure 13-20. Data projected as a collection and displayed in a grid

The application consists of a button titled “Project XML as a Collection” and a `DataGridView` control. When you click the button, data from `Employees.xml` is projected as a collection of an anonymous type. The collection is then displayed in the `DataGridView`.

Note An *anonymous type* is a type that is not explicitly defined in your code. The type name as well as its properties are inferred and generated by the compiler.

The Click event handler of the Project XML as Collection button performs the actual job of projecting the XML and is shown in Listing 13-28.

Listing 13-28. Projecting XML into a Collection

```
private void button1_Click(object sender, EventArgs e)
{
    XElement root = XElement.Load($"{Application.StartupPath}\\employees.xml");
    var employees = from item in root.Descendants("employee")
                    select new
                    {
                        EmployeeID = item.Attribute("employeeid").Value,
                        FirstName = item.Element("firstname").Value,
                        LastName = item.Element("lastname").Value,
                        HomePhone = item.Element("homephone").Value,
                        Notes = item.Element("notes").Value
                    };
    dataGridView1.DataSource = employees.ToArray();
}
```

The code loads the `Employee.xml` file into an instance of the `XElement` class. It then selects the required data as an anonymous type with five properties, namely `EmployeeID`, `FirstName`, `LastName`, `HomePhone`, and `Notes`. Finally, the collection of the anonymous type is converted to an array for data binding with the `DataGridView` control.

Summary

LINQ to XML provides an altogether new way of processing XML data. This chapter examined many features of LINQ to XML in detail. You worked with classes such as `XElement` and `XDocument` that load XML trees for processing and learned how to deal with whitespace and namespaces in LINQ to XML. Common operations such as parsing, navigating, and modifying XML data were also covered. You also learned to validate XML documents against XML Schemas. Transforming XML data using LINQ to XML has its own advantages, and you used functional construction to transform the shape of the source XML. Finally, you projected an XML tree into a collection.

APPENDIX A



Creating a Custom XmlReader and XmlWriter

In Chapter 3, you learned about the `XmlReader` and `XmlWriter` classes. The abstract classes `XmlReader` and `XmlWriter` can be used in three ways:

- To call the `Create()` method of the respective classes that return an instance of the generic `XmlReader` or `XmlWriter` classes
- To use the concrete classes `XmlTextReader` and `XmlTextWriter` provided by the .NET Framework
- To create custom classes that inherit from the `XmlReader` and `XmlWriter` classes

You are already familiar with the first two approaches. In the following sections, you are going to learn how to create custom readers and writers from the abstract base classes `XmlReader` and `XmlWriter`.

Creating a Custom XmlReader

In this section, you will create a custom implementation of the `XmlReader` class. The `SqlCommand` class provides the `ExecuteXmlReader()` method that returns an instance of `XmlReader` to the caller. This works fine if your database is SQL Server, but what if your database is Microsoft Office Access or any other OLEDB-compliant database? Moreover, XML extensions such as the FOR XML clause may not be available for all databases. Does that mean that you cannot retrieve the data and read it by using an `XmlReader`? Of course not.

There is no out-of-the-box solution for this problem, but you can build your own mechanism to overcome this limitation, by creating a custom class that inherits from the `XmlReader` abstract class. You can then override the required properties and methods as per your need. The requirements for the custom `XmlReader` class are summarized here:

- It should accept the database connection string and table name to read.
- The column values should be treated as attribute values.
- It should allow iterating through the table to read each row.
- The column values should be accessible by specifying a column index or name.

Inheriting from XmlReader

The `XmlReader` class is an abstract class and provides several properties and methods that you need to override when you inherit from it. Listing A-1 shows signatures of these properties and methods.

Listing A-1. Properties and Methods of the `XmlReader` Class

```
public abstract int AttributeCount;
public abstract string BaseURI
{
    get;
}
public abstract void Close();
public abstract int Depth
{
    get;
}
public abstract bool EOF
{
    get;
}
public abstract string GetAttribute(int i);
public abstract string GetAttribute(string name, string namespaceURI);
public abstract string GetAttribute(string name);
public abstract bool HasValue
{
    get;
}
public abstract bool IsEmptyElement
{
    get;
}
public abstract string LocalName
{
    get;
}
public abstract string LookupNamespace(string prefix);
public abstract bool MoveToAttribute(string name, string ns);
public abstract bool MoveToAttribute(string name);
public abstract bool MoveToElement();
public abstract bool MoveToFirstAttribute();
public abstract bool MoveToNextAttribute();
public abstract XmlNameTable NameTable
{
    get;
}
public abstract string NamespaceURI
{
    get;
}
```

```

public abstract XmlNodeType NodeType
{
    get;
}
public abstract string Prefix
{
    get;
}
public abstract bool Read();
public abstract bool ReadAttributeValue();
public abstract ReadState ReadState
{
    get;
}
public abstract void ResolveEntity();
public abstract string Value
{
    get;
}

```

You can override these properties and methods and write your own data-manipulation logic. If you do not want to override a particular property or method, you still need to have its empty implementation. A better way is to throw an exception in such properties and methods so that the caller knows that these properties and methods are not implemented by you. I will not discuss every property here because you are already familiar with many of them (see Chapter 3 for more information).

Creating the TableReader Class

Now that you are familiar with the `XmlReader` abstract class, let's create our own implementation. To do so, create a new project of type class library by using Visual Studio. Add a class named `TableReader`. Make sure that references to the `System.Xml` and `System.Data` assemblies are added to the project. Import the namespaces as shown in Listing A-2 at the top of the `TableReader` class and ensure that the `TableReader` class inherits from the `XmlReader` class.

Listing A-2. Importing Namespaces and Setting Inheritance

```

using System.Xml;
using System.Data;
using System.Data.OleDb;

class TableReader:XmlReader
{
    ...

```

You need to add an implementation of each property and method mentioned. Visual Studio provides a shortcut for adding empty implementations of these members. Go to the class declaration line and look for the Quick Actions icon in the left margin. Open the Quick Actions list and choose the Implement Abstract Class option (see Figure A-1).

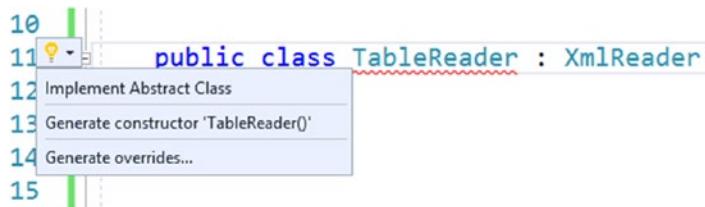


Figure A-1. Adding empty implementations of properties and methods

This will add dummy signatures of all the properties and methods that need to be overridden. Notice how the dummy implementation throws an exception by using the `throw` keyword. This way, if somebody tries to use unimplemented members, an exception will be thrown indicating that “the method or operation is not implemented.” Code the `TableReader` class as shown in Listing A-3.

Listing A-3. The `TableReader` Class

```
public class TableReader : XmlReader
{
    private OleDbConnection cnn;
    private OleDbCommand cmd;
    private OleDbDataReader reader;
    private int intColumnIndex = -1;
    private string strValue;

    public TableReader(string connectionString, string tableName)
    {
        cnn = new OleDbConnection(connectionString);
        cmd = new OleDbCommand();
        cmd.Connection = cnn;
        cmd.CommandText = tableName;
        cmd.CommandType = CommandType.TableDirect;
        cnn.Open();
        reader = cmd.ExecuteReader();
    }

    public override int AttributeCount
    {
        get
        {
            return reader.FieldCount;
        }
    }

    public override void Close()
    {
        reader.Close();
        cnn.Close();
    }
}
```

```
public override int Depth
{
    get
    {
        return reader.Depth;
    }
}

public override string GetAttribute(int i)
{
    return reader.GetValue(i).ToString();
}

public override string GetAttribute(string name)
{
    return reader.GetValue(reader.GetOrdinal(name)).ToString();
}

public override bool MoveToAttribute(string name)
{
    intColumnIndex = reader.GetOrdinal(name);
    return true;
}

public override bool MoveToElement()
{
    intColumnIndex = -1;
    return true;
}

public override bool MoveToFirstAttribute()
{
    intColumnIndex = 0;
    return true;
}

public override bool MoveToNextAttribute()
{
    intColumnIndex++;
    if (intColumnIndex > reader.FieldCount - 1)
    {
        return false;
    }
    else
    {
        return true;
    }
}
```

```

public override bool Read()
{
    intColumnIndex = -1;
    strValue = "";
    return reader.Read();
}

public override bool HasValue
{
    get
    {
        return reader.IsDBNull(intColumnIndex);
    }
}

public override bool ReadAttributeValue()
{
    if (intColumnIndex < reader.FieldCount)
    {
        strValue = reader.GetValue(intColumnIndex).ToString();
        return true;
    }
    else
    {
        return false;
    }
}

public string Name
{
    get
    {
        if (intColumnIndex == -1)
        {
            return cmd.CommandText;
        }
        else
        {
            return reader.GetName(intColumnIndex);
        }
    }
}

public override string Value
{
    get
    {
        return strValue;
    }
}

...
}

```

In the following text, we dissect the code step by step.

Declaring Class-Level Variables

```
private OleDbConnection cnn;
private OleDbCommand cmd;
private OleDbDataReader reader;
private int intColumnIndex = -1;
private string strValue;
```

The TableReader class declares private variables of type OleDbConnection, OleDbCommand, and OleDbDataReader at the class level:

- The OleDbConnection class is used to establish a connection with any OLEDB-compliant databases.
- The OleDbCommand class is used to execute any query, SQL query, or stored procedures against a database.
- The OleDbDataReader class allows you to iterate through a result set in a cursor-oriented manner.

The intColumnIndex integer variable keeps track of the current column index whose value is to be read. Similarly, the strValue string variable stores the value from the column indicated by intColumnIndex.

Initializing the Variables

```
public TableReader(string connectionString, string tableName)
{
    cnn = new OleDbConnection(connectionString);
    cmd = new OleDbCommand();
    cmd.Connection = cnn;
    cmd.CommandText = tableName;
    cmd.CommandType = CommandType.TableDirect;
    cnn.Open();
    reader = cmd.ExecuteReader();
}
```

The constructor of the TableReader class accepts two parameters: the database connection string and the name of the table whose data is to be read. Using the connection string, the OleDbConnection is instantiated. The Connection property of the OleDbCommand class is set to the OleDbConnection class we just instantiated. The CommandText property of the OleDbCommand class is set to the name of the table whose data is to be read.

Have a look at the CommandType property. It is set to TableDirect, which returns all the rows from the table indicated by the CommandText property. In effect, it works as if we have specified SELECT * FROM <tableName> as the query. The database connection is then opened. The ExecuteReader() method of OleDbCommand is called and an OleDbDataReader is retrieved.

Retrieving the Total Number of Attributes

```
public override int AttributeCount
{
    get
    {
        return reader.FieldCount;
    }
}
```

The TableReader class is going to return column values as attributes in the resultant XML data. Hence, the `AttributeCount` read-only property returns the total number of columns in the underlying table. The total number of columns in the table is obtained by using the `FieldCount` property of the `OleDbDataReader` class.

Closing the Reader

```
public override void Close()
{
    reader.Close();
    cnn.Close();
}
public override int Depth
{
    get
    {
        return reader.Depth;
    }
}
```

The `Close()` method closes the `OleDbDataReader` as well as the `OleDbConnection`. The `Depth` property returns the Depth of the `OleDbDataReader`.

Reading Attributes

```
public override string GetAttribute(int i)
{
    return reader.GetValue(i).ToString();
}

public override string GetAttribute(string name)
{
    return reader.GetValue(reader.GetOrdinal(name)).ToString();
}
```

The column values can be retrieved by using two overloads of the `GetAttribute()` method. The first overload accepts the attribute index. In our case, the attribute index is the same as the column index. The `GetValue()` method of the `OleDbDataReader` class accepts the column index and returns the column value as an object. The `ToString()` method returns a string representation of the object to the caller. The second overload accepts an attribute name. The `GetOrdinal()` method of `OleDbDataReader` accepts the column name and returns its index. The returned index is then passed to the `GetValue()` method as before.

Navigating Between the Attributes

```

public override bool MoveToAttribute(string name)
{
    intColumnIndex = reader.GetOrdinal(name);
    return true;
}

public override bool MoveToElement()
{
    intColumnIndex = -1;
    return true;
}

public override bool MoveToFirstAttribute()
{
    intColumnIndex = 0;
    return true;
}

public override bool MoveToNextAttribute()
{
    intColumnIndex++;
    if (intColumnIndex > reader.FieldCount - 1)
    {
        return false;
    }
    else
    {
        return true;
    }
}

```

The `MoveToAttribute()`, `MoveToFirstAttribute()`, `MoveToNextAttribute()`, and `MoveToElement()` methods allow you to navigate within the available attributes:

- The `MoveToAttribute()` method accepts the name of the column (which is the same as the attribute name) and sets the column index variable to the index of that column.
- The `MoveToFirstAttribute()` method sets the current column index to 0, whereas `MoveToNextAttribute()` increments it so that the next column value can be read.
- The `MoveToElement()` method simply sets the current column index to -1, indicating that no column value can be read. The `MoveToElement()` method is intended to move the reader to the element node from any of its attributes. By setting the column index to -1, we reset the column index counter and mimic this behavior.

Advancing the Reader

```
public override bool Read()
{
    intColumnIndex = -1;
    strValue = "";
    return reader.Read();
}
```

The `Read()` method allows you to iterate through the table. It calls the `Read()` method of the `OleDbDataReader` class and returns a Boolean value indicating whether the read operation was successful. As the record pointer is moving on to a new record, the current column index and value are reset.

Checking Whether the Value Is Empty

```
public override bool HasValue
{
    get
    {
        return reader.IsDBNull(intColumnIndex);
    }
}
```

The `HasValue` property indicates whether the `TableReader` contains any value. If the column contains a `NONE` value, `HasValue` should return `false`. The `IsDBNull()` method of the `OleDbDataReader` class accepts a column index and returns `true` if the column contains a `NONE` value.

Reading Values

```
public override bool ReadAttributeValue()
{
    if (intColumnIndex < reader.FieldCount)
    {
        strValue = reader.GetValue(intColumnIndex).ToString();
        return true;
    }
    else
    {
        return false;
    }
}
```

The `ReadAttributeValue()` method returns the value of the current column. It does so by using the `GetValue()` method of the `OleDbDataReader` class as before.

Returning the Table or Column Name

```
public string Name
{
    get
    {
        if (intColumnIndex == -1)
        {
            return cmd.CommandText;
        }
        else
        {
            return reader.GetName(intColumnIndex);
        }
    }
}
```

The `Name` property returns either the underlying table name or column name. This is useful to see which column is being read. The table name is obtained from the `CommandText` property of the `OleDbCommand` class, whereas the column name is obtained from the `GetName()` method of the `OleDbDataReader` class.

Returning Values

```
public override string Value
{
    get
    {
        return strValue;
    }
}
```

Finally, the `Value` property simply returns the value stored in the `strValue` variable. Note that `strValue` gets assigned in the `ReadAttributeValue()` method.

The remaining properties and methods are not implemented by the `TableReader` class. Compile the class library and you should get an assembly, `TableReader.dll`. This assembly can be used in client applications to work with OLEDB databases and XML.

Using the TableReader Class

To consume the `TableReader` class, you need to create a Windows Forms application like the one shown in Figure A-2.

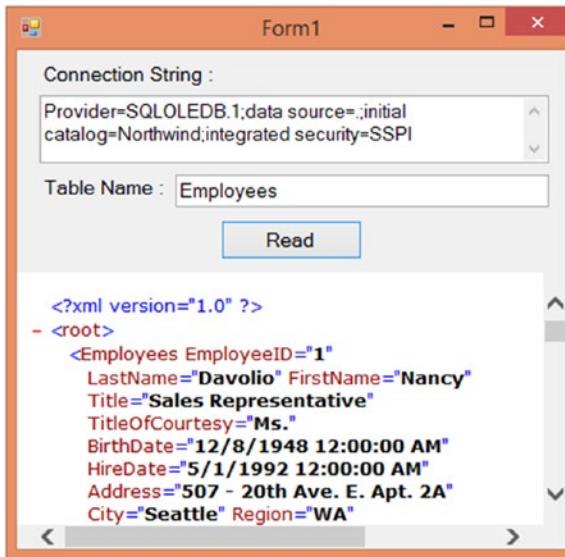


Figure A-2. Application that consumes the TableReader class

The application consists of text boxes for entering the database connection string and table name, respectively. After you click the Read button, the TableReader class is instantiated. It reads the table data and writes it to an XML file. The XML file thus created is displayed in a Web Browser control. The Click event handler of the Read button contains the code shown in Listing A-4.

Listing A-4. Using the TableReader Class

```
private void button1_Click(object sender, EventArgs e)
{
    TableReader tr = new TableReader(textBox1.Text, textBox2.Text);
    XmlTextWriter writer =
        new XmlTextWriter($"{Application.StartupPath}\\temp.xml", null);
    writer.WriteStartDocument();
    writer.WriteStartElement("root");
    int count = tr.AttributeCount;
    while (tr.Read())
    {
        writer.WriteStartElement(tr.Name);
        for (int i = 0; i < count; i++)
        {
            tr.MoveToAttribute(i);
            tr.ReadAttributeValue();
            writer.WriteString(tr.Name, tr.Value);
        }
        writer.WriteEndElement();
    }
}
```

```

writer.WriteLine();
tr.Close();
writer.Close();
webBrowser1.Navigate($"{Application.StartupPath}\\temp.xml");
}

```

Before you write the preceding code, add a reference to `TableReader.dll` in the Windows application and import the namespace at the top. The code creates an instance of the `TableReader` class by passing the database connection string and table name to its constructor. Then an `XmlTextWriter` is created that writes data to a temporary XML file called `temp.xml`. The `TableReader` class will return only the fragmented XML data; hence the root element is added by using the `WriteStartElement()` method of the `XmlTextWriter` class. The total number of columns in the supplied table is retrieved by using the `AttributeCount` property and is stored in a variable for later use.

A while loop calls the `Read()` method of the `TableReader` class. With each iteration, an element is added to the file with the same name as the table name. Recollect that the `Name` property of the `TableReader` class returns either the table name or column name depending on the current column index. Because we have just called the `Read()` method, the column index is going to be `-1` and hence the table name will be returned.

Next, a `for` loop iterates through all the attributes—that is, columns. With each iteration of the `for` loop, the value of the attribute is read by using the `ReadAttributeValue()` method. An attribute is then written to the file along with its value by using the `WriteAttributeString()` method of the `XmlTextWriter` class. The `WriteEndElement()` method of the `XmlTextWriter` class writes end tags for the nearest open element. The `TableReader` and `XmlTextReader` are then closed by using their respective `Close()` methods. Finally, the `Navigate()` method of the web browser control shows the user the XML file.

Creating a Custom XmlWriter

Now that you have created a custom implementation of `XmlReader`, let's move further and see how to create a custom `XmlWriter`. As an example, we will create an RSS writer that emits RSS feeds.

Really Simple Syndication (RSS) is a standard way to share your web site content with others. It is nothing but standardized XML markup that describes the content you want to share. Because RSS is a widely accepted format, your content immediately becomes ready to be consumed by others. Listing A-5 illustrates an RSS document.

Listing A-5. Sample RSS Markup

```

<rss version="2.0">
  <channel>
    <title>My Web Site</title>
    <link>http://localhost/mywebsite</link>
    <description>Latest Articles from My Web Site</description>
    <copyright>Copyright (C) My Web Site. All rights reserved.</copyright>
    <generator>My RSS Generator</generator>
    <item>
      <title>Using WebRequest andWebResponse</title>
      <link>http://localhost/mywebsite/displayarticle.aspx?id=239</link>
      <description>Description goes here</description>
      <pubDate>Sun, 25 Jan 2004 12:00:00 AM GMT</pubDate>
    </item>
  </channel>
</rss>

```

Let's look at each markup tag closely:

- <rss> forms the root tag and has a *version* attribute. The *version* attribute specifies the RSS specification version used by the markup, 2.0 in this case.
- <channel> contains tags such as <title>, <link>, and <item> nodes. A channel represents metadata information from a particular source. It essentially acts as a container for the rest of the tags. An RSS document can contain one or more channels.
- <title> represents the title of this RSS feed.
- <link> represents the URL of the web site providing the RSS feed.
- <description> details more information about this feed.
- <copyright> specifies copyright information.
- <generator> specifies the application that generated this feed.

In addition to the preceding tags, there can be one or more <item> tags, each of which represents an actual item that you want to share (for example, an article or a blog entry). Each <item> tag further contains the following subnodes:

- <title> represents the title of this item (for example, the article title).
- <link> represents the URL of this item (for example, the article URL).
- <description> contains the description of the item (for example, a summary of the article).
- <pubDate> contains the publication date of the item. A typical date format is Sun 28 Dec 2003 12:00:00 AM GMT.

Note The RSS markup shown here is the basic markup. You may need to add additional tags to incorporate additional information. You can obtain more information about RSS at <https://en.wikipedia.org/wiki/RSS>.

The .NET Framework provides the `System.ServiceModel.Syndication` namespace, which contains classes for reading and writing an RSS feed. However, as an example we will create our own custom class called `RssWriter`. The `RssWriter` class will inherit from `XmlWriter` and allow you to emit RSS feeds easily.

To create `RssWriter`, you need to create a class library project. As before, be sure to add a reference to the `System.Xml` assembly.

Inheriting from XmlWriter

To create a custom implementation of `XmlWriter`, you need to inherit from it and override the properties and methods shown in Listing A-6.

Listing A-6. Properties and Methods of the `XmlWriter` Class

```
public abstract void Close();
public abstract void Flush();
public abstract string LookupPrefix(string ns);
public abstract void WriteBase64(byte[] buffer, int index, int count);
```

```

public abstract void WriteCData(string text);
public abstract void WriteCharEntity(char ch);
public abstract void WriteChars(char[] buffer, int index, int count);
public abstract void WriteComment(string text);
public abstract void
    WriteDocType(string name, string pubid, string sysid, string subset);
public abstract void WriteEndAttribute();
public abstract void WriteEndDocument();
public abstract void WriteEndElement();
public abstract void WriteEntityRef(string name);
public abstract void WriteFullEndElement();
public abstract void WriteProcessingInstruction(string name, string text);
public abstract void WriteRaw(string data);
public abstract void WriteRaw(char[] buffer, int index, int count);
public abstract void
    WriteStartAttribute(string prefix, string localName, string ns);
public abstract void WriteStartDocument(bool standalone);
public abstract void WriteStartDocument();
public abstract void WriteStartElement(string prefix, string localName, string ns);
public abstract WriteState WriteState
{
    get;
}
public abstract void WriteString(string text);
public abstract void WriteSurrogateCharEntity(char lowChar, char highChar);
public abstract void WriteWhitespace(string ws);

```

Many of these properties and methods should be familiar to you because we discussed them in Chapter 3.

Creating the RssWriter Class

To begin, we need to specify that the `RssWriter` class inherits from the `XmlWriter` base class. As shown in Figure A-1, add dummy definitions of the properties and methods that implement the abstract base class `XmlWriter`. Then add a couple of variables and a constructor to the `RssWriter` class, as shown in Listing A-7.

Listing A-7. The Constructor of RssWriter

```

public class RssWriter:XmlWriter
{
    private XmlWriter writer;
    private Stream objStream;
    public RssWriter(Stream stream)
    {
        objStream = stream;
        writer = XmlWriter.Create(objStream);
    }
}

```

The code declares class-level variables of `XmlWriter` and `Stream` types, respectively. The constructor takes a parameter of type `Stream`. This stream acts as an output stream for emitting the RSS feeds. An instance of the `XmlWriter` is constructed by using the `Create()` method of the `XmlWriter` class. The stream passed to the constructor is supplied to the `Create()` method so that the newly created instance of `XmlWriter` writes to that stream.

Coding Stream-Related Operations

The stream needs to be closed and flushed to ensure that the emitted data is saved correctly. The two overridden methods—`Close()` and `Flush()`—do just that. Listing A-8 shows these methods.

Listing A-8. The `Close()` and `Flush()` Methods

```
public override void Close()
{
    objStream.Close();
    writer.Close();
}
public override void Flush()
{
    writer.Flush();
}
```

The `Close()` method calls the `Close()` method of the underlying stream as well as that of the `XmlWriter`. Similarly, the `Flush()` method calls the `Flush()` method of the `XmlWriter` so that data is flushed to the stream.

Defining Enumerations for RSS-Specific Tags

It would be nice to readily provide RSS tag and attribute names so that you need not remember them. This is achieved by creating two enumerations: `RssElements` and `RssAttributes`. The enumerations are shown in Listing A-9.

Listing A-9. Enumerations for Representing RSS Tags and Attributes

```
public enum RssElements
{
    Rss, Channel, Title, Description, Link, Copyright, Generator, Item, PubDate
}

public enum RssAttributes
{
    Version
}
```

The `RssElements` enumeration contains values for representing RSS elements. The `RssAttributes` enumeration contains just one value—`Version`—which represents the `version` attribute of the `<rss>` element.

Writing Elements

To emit the RSS feed, you need to write elements such as `<rss>` and `<item>` onto the output stream. We will create three methods for this purpose: `WriteElement()`, `WriteElementString()`, and `WriteEndElement()`. The complete code of these methods is shown in Listing A-10.

Listing A-10. Writing Elements

```
public void WriteStartElement(RssElements element)
{
    string elementName = "";
    switch (element)
    {
        case RssElements.Channel:
            elementName = "channel";
            break;
        case RssElements.Copyright:
            elementName = "copyright";
            break;
        case RssElements.Description:
            elementName = "description";
            break;
        case RssElements.Generator:
            elementName = "generator";
            break;
        case RssElements.Item:
            elementName = "item";
            break;
        case RssElements.Link:
            elementName = "link";
            break;
        case RssElements.PubDate:
            elementName = "pubDate";
            break;
        case RssElements.Rss:
            elementName = "rss";
            break;
        case RssElements.Title:
            elementName = "title";
            break;
    }
    writer.WriteStartElement(elementName);
}

public void WriteElementString(RssElements element, string value)
{
    string elementName = "";
    switch (element)
    {
        case RssElements.Channel:
            elementName = "channel";
            break;
        case RssElements.Copyright:
            elementName = "copyright";
            break;
        case RssElements.Description:
            elementName = "description";
            break;
```

```

        case RssElements.Generator:
            elementName = "generator";
            break;
        case RssElements.Item:
            elementName = "item";
            break;
        case RssElements.Link:
            elementName = "link";
            break;
        case RssElements.PubDate:
            elementName = "pubDate";
            break;
        case RssElements.Rss:
            elementName = "rss";
            break;
        case RssElements.Title:
            elementName = "title";
            break;
    }
    writer.WriteElementString(elementName, value);
}

public override void WriteEndElement()
{
    writer.WriteEndElement();
}

```

The `WriteStartElement()` method accepts a parameter of type `RssElements` that indicates the element name to be written. It contains a `switch` statement that checks the supplied element name against various values from the `RssElements` enumeration. The name of the element is stored in a string variable. Finally, the `WriteStartElement()` method of `XmlWriter` is called by supplying the element name stored in the variable.

The `WriteElementString()` method accepts two parameters: `RssElements` and the value of the element. It contains a similar `switch` statement as in the previous method and stores the element name in a variable. The `WriteElementString()` method of the `XmlWriter` class is called by passing the element name and its value. Note that `WriteStartElement()` and `WriteElementString()` are new methods—that is, they are not defined by the `XmlWriter` base class.

The `WriteEndElement()` method simply calls the `WriteEndElement()` method of the `XmlWriter` instance so that the end tag of the nearest element is emitted.

Writing Attributes

Just as we added methods for writing elements, we also need to add methods for emitting attributes. Three methods—`WriteStartAttribute()`, `WriteAttributeString()`, and `WriteEndAttribute()`—will do that job. Listing A-11 shows these methods.

Listing A-11. Writing Attributes

```

public void WriteStartAttribute(RssAttributes attb)
{
    if (attb == RssAttributes.Version)
    {
        writer.WriteStartAttribute("version");
    }
}

public void WriteAttributeString(RssAttributes attb, string value)
{
    if (attb == RssAttributes.Version)
    {
        writer.WriteAttributeString("version",value);
    }
}

public override void WriteEndAttribute()
{
    writer.WriteEndAttribute();
}

```

The `WriteStartAttribute()` method accepts a parameter of type `RssAttributes`. Inside it checks whether the attribute to be emitted is `Version`, and if so, calls the `WriteStartAttribute()` method of the `XmlWriter` instance to write the attribute.

The `WriteAttributeString()` method accepts two parameters: `RssAttributes` and the value of the attribute. It then calls the `WriteAttributeString()` method of the `XmlWriter` instance by passing the supplied value and `version` as the attribute name.

The `WriteEndAttribute()` method simply calls the `WriteEndAttribute()` method of the `XmlWriter` instance.

Writing Data

Although the methods that we created for writing elements will take care of most of the RSS feed generation, you may need additional methods to emit comments, character data, whitespaces, and so on. To accomplish this task, we will write a set of methods, as shown in Listing A-12.

Listing A-12. Methods for Writing Data

```

public override void WriteCData(string text)
{
    writer.WriteCData(text);
}

public override void WriteChars(char[] buffer, int index, int count)
{
    writer.WriteChars(buffer, index, count);
}

```

```

public override void WriteComment(string text)
{
    writer.WriteComment(text);
}

public override void WriteWhitespace(string ws)
{
    writer.WriteWhitespace(ws);
}

public override void WriteString(string text)
{
    writer.WriteString(text);
}

```

These methods do not contain much code. They simply call the corresponding method on the `XmlWriter` instance. For example, the `WriteCData()` method accepts a string and calls the `WriteCData()` method of the `XmlWriter` by passing the string. The `WriteChars()`, `WriteComment()`, `WriteWhitespace()`, and `WriteString()` methods also call the respective methods of the `XmlWriter` instance.

Writing an XML Declaration

An RSS feed is an XML document and from that point of view should contain an XML declaration. The methods `WriteStartDocument()` and `WriteEndDocument()` emit an XML declaration with a version of 1.0. These methods are shown in Listing A-13.

Listing A-13. Writing an XML Declaration

```

public override void WriteStartDocument()
{
    writer.WriteStartDocument();
}
public override void WriteStartDocument(bool standalone)
{
    writer.WriteStartDocument(standalone);
}
public override void WriteEndDocument()
{
    writer.WriteEndDocument();
}

```

The `WriteStartDocument()` method has two overloads. The one with a Boolean parameter emits a stand-alone attribute. Both the methods call respective overloads of the `WriteStartDocument()` method on the `XmlWriter` instance. The `WriteEndDocument()` method simply calls the `WriteEndDocument()` method of the `XmlWriter` instance.

That's it: the `RssWriter` class is now ready. Compile the class library to get its output assembly.

Using the RssWriter Class

To consume the RssWriter class we just created, you will need to create a new web site in Visual Studio. Add a reference to the assembly in which RssWriter resides. Open the default web form in the IDE and write the code shown in Listing A-14 in its Page_Load event handler.

Listing A-14. Using the RssWriter Class

```
protected void Page_Load(object sender, EventArgs e)
{
    Response.ContentEncoding = System.Text.Encoding.UTF8;
    Response.ContentType = "text/xml";
    RssWriter writer = new RssWriter(Response.OutputStream);
    writer.WriteStartElement(RssElements.Rss);
    writer.WriteAttributeString(RssAttributes.Version, "2.0");
    writer.WriteStartElement(RssElements.Channel);
    writer.WriteLineString(RssElements.Title, "My Web Site");
    writer.WriteLineString(RssElements.Link, "http://localhost/mywebsite");
    writer.WriteLineString(RssElements.Description, "Latest Articles from My Web Site");
    writer.WriteLineString(RssElements.Copyright, "Copyright (C) My Web Site. All rights
reserved.");
    writer.WriteLineString(RssElements.Generator, "My XML RSS Generator");
    writer.WriteStartElement(RssElements.Item);
    writer.WriteLineString(RssElements.Title, "Create and consume RSS Feeds");
    writer.WriteLineString(RssElements.Link, "http://localhost/mywebsite/Articles/
displayarticle.aspx?id=242");
    writer.WriteLineString(RssElements.Description, "This article explains how to create
and consume RSS feeds.");
    writer.WriteLineString(RssElements.PubDate, "Mon, 04 Sep 2017 12:00:00 AM GMT");
    writer.WriteEndElement();
    writer.WriteEndElement();
    writer.Close();
    Response.End();
}
```

The code sets the ContentEncoding property of the Response object to UTF-8 (that is, ASCII). It also sets the ContentType property to text/xml. This way, the browser knows that the response is XML data rather than HTML. A new instance of the RssWriter class is then created. The OutputStream of the Response object is passed as a parameter to the constructor of the RssWriter class. This way, the XML data will be written directly on the response stream.

Then, one by one, RSS tags are emitted so as to output an RSS feed, as shown in Listing A-5 earlier. Notice how the RssElements enumeration has made our job easy. Various methods, such as WriteElementString() and WriteStartElement(), make extensive use of the RssElements enumeration. After the feed has been written, the RssWriter instance is closed. Finally, the End() method of the Response object is called so that the response stream is flushed off to the client.

Note For the sake of simplicity, the code emits hard-coded values. In most real-world cases, you will retrieve data such as the title, URL, and publication date from a database table.

If you run the web form after writing the code, it should look similar to Figure A-3.

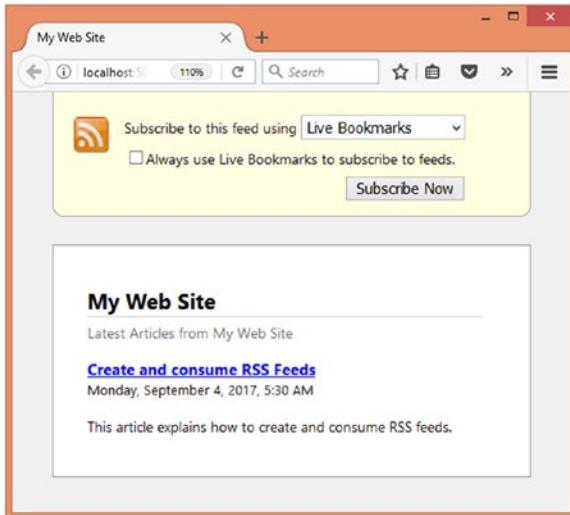


Figure A-3. RSS feed displayed in the browser

As you can see, Firefox has identified the response as a valid RSS feed and displayed in a special way for easy reading. If you view the Page Source of the page, you will see the raw XML markup, as shown in Figure A-4.

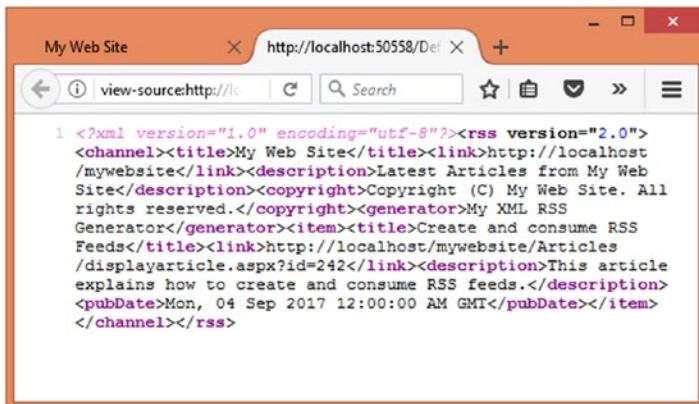


Figure A-4. Raw XML of the RSS feed

This is the same RSS feed markup you emitted from the web form code-behind.

Summary

In this appendix, you learned to create custom implementations of the `XmlReader` and `XmlWriter` classes. The `XmlReader` and `XmlWriter` classes are abstract classes. To create custom readers and writers, you need to inherit from them and override various properties and methods. This way, you can easily extend the out-of-the-box functionality exposed by these classes for specific scenarios.

APPENDIX B



Resources

The following resources will help you learn more about XML, .NET Framework, and allied technologies.

W3C Web Site for XML Specifications

<http://www.w3.org/XML>

W3C Web Site for XML Schema Specifications

<http://www.w3.org/XML/Schema>

W3C Web Site for XPath-Related Information

<http://www.w3.org/TR/xpath>

W3C Web Site for XSL-Related Information

<http://www.w3.org/Style/XSL>

W3C Web Site for SOAP Specifications

<https://www.w3.org/TR/soap>

System.Xml Reference

<https://msdn.microsoft.com/library/system.xml.aspx>

.NET/ASP.NET/WCF/Web API

<https://www.microsoft.com/net>

<https://www.asp.net>

<https://docs.microsoft.com/en-us/dotnet/framework/wcf>

<https://docs.microsoft.com/en-us/aspnet/web-api>

Wikipedia—XML Section

<http://en.wikipedia.org/wiki/XML>

Author's Web Site on .NET and Web Development

<http://www.binaryintellect.net>

XML Notepad—XML Editor

<https://github.com/microsoft/xmlnotepad>

Sandcastle Help File Builder

<https://github.com/EWSoftware/SHFB>

SQLXML Programming

<https://docs.microsoft.com/en-us/sql/relational-databases/sqlxml/sqlxml-4-0-programming-concepts>

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