Microsoft® ADO.NET 4
Step by Step

Tim Patrick
To Abel Chan, a good friend and a good programmer.
## Contents at a Glance

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Tim Patrick
October 2010
Introduction

ADO.NET is Microsoft’s core data access library for .NET developers, and is the heart of many data-centric technologies on the Windows development platform. It works with C#, Visual Basic, and other .NET-enabled languages. If you are a .NET developer looking to interact with database content or other external data sources, then ADO.NET is the right tool for you.

*Microsoft ADO.NET 4 Step by Step* provides an organized walkthrough of the ADO.NET library and its associated technologies. The text is decidedly introductory; it discusses the basics of each covered system, with examples that provide a great head start on adding data features to your applications. While the book does not provide exhaustive coverage of every ADO.NET feature, it does offer essential guidance in using the key ADO.NET components.

In addition to its coverage of core ADO.NET library features, the book discusses the Entity Framework, the LINQ query system, and WCF Data Services. Beyond the explanatory content, each chapter includes step by step examples and downloadable sample projects that you can explore for yourself.

Who Is This Book For?

As part of Microsoft Press’s “Developer Step By Step” series of training resources, *Microsoft ADO.NET 4 Step by Step* makes it easy to learn about ADO.NET and the advanced data tools used with it.

This book exists to help existing Visual Basic and C# developers understand the core concepts of ADO.NET and related technologies. It is especially useful for programmers looking to manage database-hosted information in their new or existing .NET applications. Although most readers will have no prior experience with ADO.NET, the book is also useful for those familiar with earlier versions of either ADO or ADO.NET, and who are interested in getting filled in on the newest features.

*Assumptions*

As a reader, the book expects that you have at least a minimal understanding of .NET development and object-oriented programming concepts. Although ADO.NET is available to most, if not all, .NET language platforms, this book includes examples in C# and Visual Basic only. If you have not yet picked up one of those languages, you might consider reading John Sharp’s *Microsoft Visual C# 2010 Step by Step* (Microsoft Press 2010) or Michael Halvorson’s *Microsoft Visual Basic 2010 Step by Step* (Microsoft Press 2010).

With a heavy focus on database concepts, this book assumes that you have a basic understanding of relational database systems such as Microsoft SQL Server, and have had brief
exposure to one of the many flavors of the query tool known as SQL. To go beyond this book and expand your knowledge of SQL and Microsoft's SQL Server database platform, other Microsoft Press books such as Mike Hotek's *Microsoft® SQL Server® 2008 Step by Step* (Microsoft Press, 2008) or Itzik Ben-gan's *Microsoft® SQL Server® 2008 T-SQL Fundamentals* (Microsoft Press, 2008) offer both complete introductions and comprehensive information on T-SQL and SQL Server.

**Organization of This Book**

This book is divided into five sections, each of which focuses on a different aspect or technology within the ADO.NET family. Part I, “Getting to Know ADO.NET,” provides a quick overview of ADO.NET and its fundamental role in .NET applications, then delves into the details of the main ADO.NET library, focusing on using the technology without yet being concerned with external database connections. Part II, “Connecting to External Data Sources,” continues that core library focus, adding in the connectivity features. Part III, “Entity Framework,” introduces the Entity Framework, Microsoft’s model-based data service. Another service layer, LINQ, takes center stage in Part IV, “LINQ.” Finally, Part V, “Presenting Data to the World,” covers some miscellaneous topics that round out the full discussion of ADO.NET.

**Finding Your Best Starting Point in This Book**

The different sections of *Microsoft ADO.NET 4 Step by Step* cover a wide range of technologies associated with the data library. Depending on your needs and your existing understanding of Microsoft data tools, you may wish to focus on specific areas of the book. Use the following table to determine how best to proceed through the book.

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<td>Focus on Parts I and II and on Chapter 21 in Part V, or read through the entire book in order.</td>
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| Familiar with earlier releases of ADO.NET | Briefly skim Parts I and II if you need a refresher on the core concepts.  
Read up on the new technologies in Parts III and IV and be sure to read Chapter 22 in Part V. |
| Interested in the Entity Framework      | Read Part III. Chapter 22 in Part V discusses data services built on top of Entity Framework models. |
| Interested in LINQ data providers       | Read through the chapters in Part IV.                                            |

Most of the book’s chapters include hands-on samples that let you try out the concepts just learned. No matter which sections you choose to focus on, be sure to download and install the sample applications on your system.
Conventions and Features in This Book

This book presents information using conventions designed to make the information readable and easy to follow.

■ In most cases, the book includes separate exercises for Visual Basic programmers and Visual C# programmers. You can skip the exercises that do not apply to your selected language.

■ Each exercise consists of a series of tasks, presented as numbered steps (1, 2, and so on) listing each action you must take to complete the exercise.

■ Boxed elements with labels such as “Note” provide additional information or alternative methods for completing a step successfully.

■ Text that you type (apart from code blocks) appears in bold.

■ A plus sign (+) between two key names means that you must press those keys at the same time. For example, “Press Alt+Tab” means that you hold down the Alt key while you press the Tab key.

■ A vertical bar between two or more menu items (e.g. File | Close), means that you should select the first menu or menu item, then the next, and so on.

System Requirements

You will need the following hardware and software to complete the practice exercises in this book:


■ Visual Studio 2010, any edition (multiple downloads may be required if using Express Edition products)

■ SQL Server 2008 Express Edition or higher (2008 or R2 release), with SQL Server Management Studio 2008 Express or higher (included with Visual Studio, Express Editions require separate download)

■ Computer that has a 1.6GHz or faster processor (2GHz recommended)

■ 1 GB (32 Bit) or 2 GB (64 Bit) RAM (add 512 MB if running in a virtual machine or SQL Server Express Editions; more for advanced SQL Server editions)

■ 3.5GB of available hard disk space

■ 5400 RPM hard disk drive
Microsoft ADO.NET 4 Step by Step

- DirectX 9 capable video card running at 1024 x 768 or higher-resolution display
- DVD-ROM drive (if installing Visual Studio from DVD)
- Internet connection to download software or chapter examples

Depending on your Windows configuration, you might need Local Administrator rights to install or configure Visual Studio 2010 and SQL Server 2008 products.

## Code Samples

Most of the chapters in this book include exercises that let you interactively try out new material learned in the main text. All sample projects, in both their pre-exercise and post-exercise formats, are available for download from the book’s catalog page online:

http://aka.ms/638884/files

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**Note** In addition to the code samples, your system should have Visual Studio 2010 and SQL Server 2008 installed. The instructions below use SQL Server Management Studio 2008 to set up the sample database used with the practice examples. If available, install the latest service packs for each product.

## Installing the Code Samples

Follow these steps to install the code samples on your computer so that you can use them with the exercises in this book.

1. Open the *file that you downloaded from the book’s web site*.

2. Copy the entire contents of the opened .zip file to a convenient location on your hard disk.
Installing the Sample Database

Follow these steps to install the sample database used by many of the book’s practice examples.

**Note** You must first download and install the Code Samples using the instructions listed above. Also, you must have both SQL Server 2008 and SQL Server Management Studio 2008 installed, any edition.


2. In the Object Explorer panel, right-click on the Databases branch of the connection tree, and select New Database from the shortcut menu.

3. When the New Database dialog box appears, enter **StepSample** in the Database Name field. Click OK to create the database.
4. Select File | Open | File from the main SQL Server Management Studio menu, and locate the \textit{DB Script.sql} file installed with the book's sample projects. This file appears in the \textit{Sample Database} folder within the main installation folder.

5. Click the Execute button on the SQL Editor toolbar to run the script. This will create the necessary tables and objects needed by the practice examples.


\textbf{Using the Code Samples}

The main installation folder extracted from the \textit{ADO.NET 4 SBS Examples.zip} file contains three subfolders.

- \textit{Sample Database}  This folder contains the SQL script used to build the sample database. The instructions for creating this database appear earlier in this Introduction.

- \textit{Exercises}  The main example projects referenced in each chapter appear in this folder. Many of these projects are incomplete, and will not run without following the steps indicated in the associated chapter. Separate folders indicate each chapter's sample code, and there are distinct folders for the C# and Visual Basic versions of each example.

- \textit{Completed Exercises}  This folder contains all content from the Exercises folder, but with chapter-specific instructions applied.
To complete an exercise, access the appropriate chapter-and-language folder in the Exercises folder, and open the project file. If your system is configured to display file extensions, Visual Basic project files use a .vbproj extension, while C# project files use .csproj as the file extension.

**Uninstalling the Code Samples**

To remove the code samples from your system, simply delete the installation folder that you extracted from the .zip file.

**Software Release**

This book was written for use with Visual Studio 2010, including the Express Editions products. Much of the content will apply to other versions of Visual Studio, but the code samples may be not be fully compatible with earlier or later versions of Visual Studio.

The practice examples in the book use SQL Server 2008, including the Express Edition products. Many of the examples may work with SQL Server 2005 or earlier versions, but neither the installation script nor the sample projects have been tested with those earlier releases.

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Part I
Getting to Know ADO.NET

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Chapter 2: Building Tables of Data
Chapter 3: Storing Data in Memory
Chapter 4: Accessing the Right Data Values
Chapter 5: Bringing Related Data Together
Chapter 6: Turning Data into Information
Chapter 7: Saving and Restoring Data
Chapter 1
Introducing ADO.NET 4

After completing this chapter, you will be able to:

- Identify what ADO.NET is
- Explain ADO.NET’s role in an application
- Identify the major components that make up ADO.NET
- Create an ADO.NET link between a database and a .NET application

This chapter introduces you to ADO.NET and its purpose in the world of Microsoft .NET application development. ADO.NET has been included with the .NET Framework since its initial release in 2002, playing a central role in the development of both desktop and Internet-targeted applications for programmers using C#, Visual Basic, and other Framework languages.

What Is ADO.NET?

ADO.NET is a family of technologies that allows .NET developers to interact with data in standard, structured, and primarily disconnected ways. If that sounds confusing, don’t worry. This book exists to remove the confusion and anxiety that many developers experience when they first learn of ADO.NET’s multiple object layers, its dozens of general and platform-specific classes, and its myriad options for interacting with actual data.

Applications written using the .NET Framework depend on .NET class libraries, which exist in special DLL files that encapsulate common programming functionality in an easy-to-access format. Most of the libraries supplied with the .NET Framework appear within the System namespace. System.IO, for instance, includes classes that let you interact with standard disk files and related data streams. The System.Security library provides access to, among other things, data encryption features. ADO.NET, expressed through the System.Data namespace, implements a small set of libraries that makes consuming and manipulating large amounts of data simple and straightforward.

ADO.NET manages both internal data—data created in memory and used solely within an application—and external data—data housed in a storage area apart from the application, such as in a relational database or text file. Regardless of the source, ADO.NET generalizes the relevant data and presents it to your code in spreadsheet-style rows and columns.
Note: Although ADO.NET manipulates data in tabular form, you can also use ADO.NET to access nontabular data. For instance, an ADO.NET provider (discussed later in the chapter, on page 7) could supply access to hierarchical data such as that found in the Windows Registry, as long as that provider expressed the data in a tabular structure for ADO.NET’s use. Accessing such nontabular data is beyond the scope of this book.

If you are already familiar with relational databases such as Microsoft SQL Server, you will encounter many familiar terms in ADO.NET. Tables, rows, columns, relations, views; these ADO.NET concepts are based loosely on their relational database counterparts. Despite these similarities, ADO.NET is not a relational database because it doesn’t include key “relational algebra” features typically found in robust database systems. It also lacks many of the common support features of such databases, including indexes, stored procedures, and triggers. Still, if you limit yourself to basic create, read, update, and delete (CRUD) operations, ADO.NET can act like a miniature yet powerful in-memory database.

As an acronym, “ADO.NET” stands for—nothing. Just like the words “scuba,” “laser,” and “NT” in Windows NT, the capital letters in ADO.NET used to mean something, but now it is just a standalone term. Before Microsoft released the .NET Framework, one of the primary data access tools Windows developers used in their programs was known as ADO, which did stand for something: ActiveX Data Objects. After .NET arrived on the scene, ADO.NET became the natural successor to ADO. Although conceptual parallels exist between ADO.NET and ADO, the technologies are distinct and incompatible.

Note: ADO is based on Microsoft’s older COM technology. The .NET Framework provides support for COM components, and therefore enables .NET programs to use ADO. This is especially useful for development teams transitioning legacy applications to .NET. Although ADO and ADO.NET components can appear in the same application, they can interact only indirectly because their object libraries are unrelated.

When communicating with external data stores, ADO.NET presents a disconnected data experience. In earlier data platforms, including ADO, software developers would typically establish a persistent connection with a database and use various forms of record locking to manage safe and accurate data updates. But then along came the Internet and its browser-centric view of information. Maintaining a long-standing data connection through bursts of HTTP text content was no longer a realistic expectation. ADO.NET’s preference toward on-again, off-again database connections reflects this reality. Although this paradigm change brought with it difficulties for traditional client-server application developers, it also helped usher in the era of massive scalability and n-tier development that is now common to both desktop and Web-based systems.
Why ADO.NET?

In the early days of computer programming, the need for a data library like ADO.NET didn’t exist. Programmers had only a single method of accessing data: direct interaction with the values in memory. Permanently stored data existed on tape reels in fire-resistant, climate-controlled, raised-floor rooms. Data queries could take hours, especially if someone with more clout had a higher-priority processing need.

Over time, computers increased in complexity, and (as if to fill some eternal maxim) data processing needs also expanded to consume all available computing resources. Businesses sought easier ways to manage entire records of numeric, text, and date-time values on their mainframe systems. Flat-file and relational database systems sprang up to establish proprietary management of millions of data values. As personal computers arrived and matured, developers soon had several database systems at their disposal.

This was great news for data consumers. Businesses and individuals now had powerful tools to transform data bits into usable information, to endow seemingly unrelated values with meaning and purpose. But it was bad news for developers. As technology marched on, companies purchased one proprietary system after another. Programming against such systems meant a reinvention of the proverbial wheel each time a middle manager asked for yet another one-time report. Even the standard SQL language brought little relief because each database vendor provided its own spin on the meaning of “standard.”

What programmers needed was a way to generalize different data systems in a standard, consistent, and powerful way. In the world of .NET application development, Microsoft ADO.NET meets that need. Instead of worrying about the minutiae associated with the different database systems, programmers using ADO.NET focus on the data content itself.

Major Components of ADO.NET

The System.Data namespace includes many distinct ADO.NET classes that work together to provide access to tabular data. The library includes two major groups of classes: those that manage the actual data within the software and those that communicate with external data systems. Figure 1-1 shows the major parts that make up an ADO.NET instance.
At the data-shaped heart of the library is the **DataTable**. Similar in purpose to tables in a database, the **DataTable** manages all the actual data values that you and your source code ultimately care about. Each **DataTable** contains zero or more rows of data, with the individual data values of each row identified by the table’s column definitions.

- Each table defines **DataColumn** items, each representing the individual data values that appear in the table’s records. **DataColumn** definitions include a data type declaration based on the kind of data destined for each column. For instance, a **CustomerLastName** column might be defined to use data of type **System.String**, whereas an **OrderSalesTax** column could be crafted for use with **System.Decimal** content.

- One **DataRow** entry exists for each record of data stored within a table, providing access to the distinct columnar data values. ADO.NET includes methods that let you add to, delete from, modify, and query each **DataTable** object’s rows. For tables connected to an external data storage area, any changes made can be propagated back to the source.

- You can optionally establish links between the tables of data using **DataRelation** entries.
Programmatic limitations can be placed on tables and their data values using Constraint instances.

DataView instances provide a limited or modified view of the rows in a DataTable.

Tables can be grouped together into a Dataset. Some tools that interact with ADO.NET data require that any tables be bound within a Dataset, but if you plan to do some limited work with only a single table, it’s fine to work with just the DataTable instance.

DataTable instances and their associated objects are sufficient for working with internal data. To connect with external data from a database, ADO.NET features multiple data providers, including a custom provider for Microsoft SQL Server. Database platforms without a specific provider use the more generic ODBC and OLE DB providers, both included with ADO.NET. Several third-party providers can be purchased or obtained free of charge, which target specific platforms, including Oracle.

All communication with the external data source occurs through a Connection object. ADO.NET supports connection pooling for increased efficiency between queries.

SQL queries and data management statements get wrapped in a Command object before being sent to the data source. Commands can include optional Parameter instances that let you call stored procedures or create fill-in-the-blank queries.

The DataAdapter object stores standard query definitions for interacting with a database, removing the tedium of constantly needing to build SQL statements for each record you want to read or write, and helping to automate some ADO.NET-related tasks.

The DataReader object provides fast, read-only access to the results of a query for those times when you just need to get your data quickly.

ADO.NET also includes features that let you save an entire DataSet as an XML file and load it back in later. And that’s just the start. You’ll learn how to use all these elements—and more—throughout the upcoming chapters.

Extensions to ADO.NET

Generalizing access to data is a key benefit of using ADO.NET. But an even greater advantage for .NET developers is that all values managed through ADO.NET appear as objects, first-class members of the .NET data world. Each data field in a table is a strongly typed data member, fully compliant with .NET’s Common Type System. Individual fields can be used just like any other local variable. Data rows and other sets of objects are standard .NET collections and can be processed using standard iteration methods.
Because ADO.NET values exist as true .NET objects and collections, Microsoft has enhanced the core ADO.NET feature set with new tools. Two of these technologies, the Entity Framework and LINQ, are not formally part of ADO.NET. But their capability to interact with and enhance the ADO.NET experience makes them essential topics for study.

The Entity Framework, the focus of Part III of this book, emphasizes the conceptual view of your data. Although the data classes in ADO.NET are programmer-friendly, you still need to keep track of primary keys and relationships between tables and fields. The Entity Framework attempts to hide that messiness, and restores the promise of what object-oriented programming was supposed to be all about. In the Entity Framework, a customer object includes its orders; each order includes line item details. Instead of working with the raw table data, you interact with logically designed entities that mimic their real-world counterparts, and let the Framework worry about translating it all into SQL statements.

LINQ, introduced in Part IV, brings the joy of English-like queries to your favorite programming language. Microsoft enhanced both Visual Basic and C# with new LINQ-specific language features. Now, instead of building string-based SQL statements to query data, the syntax of each programming language becomes the query language. LINQ is a generic data tool, enabling you to easily mix ADO.NET data and other content sources together into a single set of results.

Connecting to External Data

Chapter 8, “Establishing External Connections,” introduces the code elements that support communications between ADO.NET and external sources of data. Although using only code to establish these connections is quite common, Visual Studio also includes the Data Source Connection Wizard, a mouse-friendly tool that guides you through the creation of a ready-to-use Dataset. Here’s an example of using the Connection Wizard.

Creating a Data Source Using the Connection Wizard

   ADO.NET is supported in most common project types. To keep things simple for now, create a Windows Forms application using either C# or Visual Basic as the language. The following figures show the process using a Visual Basic Windows Forms application, although the steps are identical in C#.

2. In the New Project dialog box, provide a name for the project.

3. Click OK.
   Visual Studio will create a project.
4. Select Data | Add New Data Source from the menu. Visual Studio displays the Data Source Configuration Wizard.

The Database choice should already be selected in the Choose A Data Source Type panel.
5. Click Next.

6. In the Choose a Database Model panel, choose Dataset.

7. Click Next.

   The Wizard displays the Choose Your Data Connection panel. If you previously configured data sources, they will appear in the Which Data Connection Should Your Application Use To Connect To The Database? list.

8. Because you are setting up a connection to the test database for the first time, click the New Connection button.
9. When the Choose Data Source dialog box appears, select Microsoft SQL Server from the Data Source list.

The Data Provider field will automatically choose the SQL Server data provider. For maximum flexibility, clear the Always Use This Selection field.

Note Choosing Microsoft SQL Server will access a database that has previously been attached to a SQL Server database instance. To create a data source that directly references a database file not necessarily attached to the engine instance, select Microsoft SQL Server Database File from the Data Source list instead. The wizard will then prompt you for the disk location of the file.
10. Click Continue to accept the data source.

11. In the Add Connection dialog box, select the server from the Server Name field. For SQL Server 2008 Express Edition instances, this is typically the name of the local computer with \SQLEXPRESS appended to the name. If you are using the full SQL Server product, leave off the \SQLEXPRESS suffix. For SQL Server instances hosted on the same system as your Visual Studio installation, you can use (local) as the server name.

For SQL Server instances configured with database-managed authentication, select Use SQL Server Authentication and supply the appropriate user name and password. For databases managed with Windows authentication (the likely choice for the test database), select Use Windows Authentication instead.

The Select Or Enter a Database Name field should now include the available databases within the test database file. (If not, confirm that you have supplied the right server name and authentication values and that SQL Server is running on your system.)

12. Select StepSample (or the name of your primary test database) from the list. Then click OK to complete the connection configuration.

Control returns to the wizard with the new data connection selected in the list on the Choose Your Data Connection panel.
ADO.NET uses connection strings, short, semicolon-delimited definition strings, to identify the data source. As you develop new applications, you will probably forgo the Data Source Configuration Wizard as a means of building connection strings. If you are curious about what appears in a connection string, expand the Connection String field in the Choose Your Data Connection panel.

13. Click the Next button to continue.

The next wizard panel asks if the connection string should be stored in the application’s configuration file. The field should already be selected, which is good, although you might want to give it a more programmer-friendly name.

.NET applications use two types of configuration files (although it varies by project type): application configuration files and user configuration files. Although your application has access to the settings in both files, if you plan to include a feature in your program that modifies these saved settings, make sure that you place such settings in the user configuration file. Application configuration files can’t be modified from within the associated application.

14. Click the Next button once more to continue.

SQL Server will perform a quick analysis of your database, compiling a list of all available data-exposing items, including tables, views, stored procedures, and functions. The Choose Your Database Objects panel displays all items found during this discovery process.
15. For this test, include the Customer table in the DataSet by expanding the Tables section and marking the Customer table with a check mark.

You can optionally modify the DataSet Name field to something that will be easier to repeatedly type in your source code. Click Finish to exit the wizard and create the data source. The data source is now available for use in your application.

16. Select Data | Show Data Sources from the Visual Studio menu to see the data source.

The wizard also added a new .xsd file to your project; it appears in the Solution Explorer with your other project files. This XML file contains the actual definition of the data source. Removing this file from the project removes the Wizard-created data source.

![Image showing Visual Studio with Data Source and New .xsd File]

Visual Studio also lets you preview the data records within the data source.

17. Select Data | Preview Data from the Visual Studio menu to open the Preview Data dialog box.

The menu choice might be hidden depending on what is currently active in the Visual Studio IDE. If that menu choice does not appear, click the form in the design window and then try to select the menu item again.
Summary

This chapter provided an overview of Microsoft’s ADO.NET technology and its major data management components. At its heart, computer programming is all about data manipulation, whether the data values represent customer records, characters and objects in a 3D interactive video game, or the bits in a compressed audio file. With this inherent focus on data, it makes sense that Microsoft would provide a great tool for interacting with tabular data, one of the most useful ways of organizing data, especially in a business setting.

As you will see in upcoming chapters, the concepts included in this opening chapter have direct ties to specific ADO.NET classes and class members. As a .NET developer, you already have a core understanding of how ADO.NET can be used in an application because everything in the library is expressed as standard .NET objects. The only things you still need to learn are some of the details that are specific to ADO.NET—the very subjects covered in the rest of this book.
# Chapter 1 Quick Reference

<table>
<thead>
<tr>
<th>To</th>
<th>Do This</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create a new data source</td>
<td>Create or open a project in Visual Studio. Select Data</td>
</tr>
<tr>
<td>Preview data in an existing data source</td>
<td>Select Data</td>
</tr>
<tr>
<td>Remove a data source from a project</td>
<td>Select the .xsd file in the Solution Explorer. Press the Delete key or right-click on the file and select Delete from the shortcut menu.</td>
</tr>
</tbody>
</table>
Chapter 3
Storing Data in Memory

After completing this chapter, you will be able to:

- Explain how a DataTable stores data
- Add new data rows to a table
- Examine, update, and remove existing values in a table row
- Explain how ADO.NET differentiates between pending and final data values
- Integrate data verification code into your DataTable object

Adding columns to a DataTable is an essential step in managing data in ADO.NET, but the columns themselves contain no data. To store actual data values in an ADO.NET table, you must use the DataRow class. After you place one or more data rows in a table, the real work of managing application-specific information begins. This chapter introduces the DataRow class and its role in data storage within each data table.

Note The exercises in this chapter all use the same sample project, a simple editor of DataRow records within a single DataTable. Although you will be able to run the application after each exercise, the expected results for the full application might not appear until you complete all exercises in the chapter.

Adding Data

Adding new data rows to a table is a three-step process:

1. Create a new row object.
2. Store the actual data values in the row object.
3. Add the row object to the table.

Creating New Rows

The DataColumn objects you add to a DataTable let you define an unlimited number of column combinations. One table might manage information on individuals, with textual name fields and dates for birthdays and driver-license expirations. Another table might exist to track the score in a baseball game, and contain no names or dates at all. The type of information you store in a table depends on the columns included in that table, along with the name, data type, and field constraints for each column.
The `DataRow` class lets you store a single row of data in a table. However, a row of data that tracks customers or medical patients is not the same as a row that tracks baseball scores. The columns differ in number, data types, and even their names and positions. Therefore, each ADO.NET `DataRow` must be configured to work with a specific `DataTable` and its collection of `DataColumn` instances.

The `DataTable` class includes the `NewRow` method to generate table-specific data rows. Whenever you want to add a new row of data to a table, the first step always involves generating a new `DataRow` with the `NewRow` method.

```csharp
DataRow oneRow = someTable.NewRow();
```

```visualbasic
Dim oneRow As DataRow = someTable.NewRow()
```

The generated row includes information about each data column defined for the table. Typically, the data associated with each column in the new row is initially NULL, the database state for an unassigned field. However, if a `DataColumn` definition includes a `DefaultValue` setting, that initial value will appear immediately in the generated row for the named column. Also, any column that has its `AutoIncrement` and related fields set (typically a primary key field) will include generated sequential values for that column.

### Defining Row Values

The `DataRow` class includes an `Item` property that provides access to each defined column, by name, zero-based index number, or reference to the physical `DataColumn` instance. When writing code with a specific table format in mind, programmers generally use the column-name method because it makes clear which field is being referenced in a code statement.

```csharp
oneRow.Item["ID"] = 123;         // by column name
oneRow.Item[0] = 123;            // by column position
DataColumn whichColumn = someTable.Columns[0];
oneRow.Item[whichColumn] = 123;  // by column instance
```

```visualbasic
oneRow.Item("ID") = 123         ' by column name
oneRow.Item(0) = 123            ' by column position
Dim whichColumn As DataColumn = someTable.Columns(0)
oneRow.Item(whichColumn) = 123  ' by column instance
```
Because `Item` is the default member for the `DataRow` class, you can omit the name when referencing row values, as shown here:

```csharp
C#
oneRow["ID"] = 123;

Visual Basic
oneRow("ID") = 123
```

Visual Basic includes a special “exclamation point” syntax that condenses the statement even more, but you can use it only with column names, not with column indexes.

```visualbasic
Visual Basic
oneRow!ID = 123
```

**Note** Members of the `Item` class are defined as the generic `Object` type; they are not strongly typed to the data type defined for the columns. This means that you can store data of an incorrect type in any field during this assignment phase. Errors will not be reported until you attempt to add the `DataRow` object to the table’s `Rows` collection, as described in the “Storing Rows in a Table” section of this chapter on page 40.

As you assign values to a row, they become available immediately for use in other expressions.

```csharp
C#
orderData["Subtotal"] = orderRecord.PreTaxTotal;
orderData["SalesTax"] = orderRecord.PreTaxTotal * orderRecord.TaxRate;
orderData["Total"] = orderData["Subtotal"] + orderData["SalesTax"];

Visual Basic
orderData!Subtotal = orderRecord.PreTaxTotal
orderData!SalesTax = orderRecord.PreTaxTotal * orderRecord.TaxRate
orderData!Total = orderData!Subtotal + orderData!SalesTax
```
Fields with no default or auto-increment value are automatically set to NULL. If for any reason you need to set a field to NULL from a non-NULL state, assign it with the value of .NET’s `DBNull` class.

```csharp
C#
oneRow["Comments"] = System.DBNull.Value;

Visual Basic
oneRow!Comments = System.DBNull.Value
```

As mentioned in Chapter 2, “Building Tables of Data,” you can test field values in C# using the `DBNull.Value.Equals` method or in Visual Basic with the `IsDBNull` function. The `DataRow` class includes its own `IsNull` method; it is functionally equivalent to the methods from Chapter 2. Instead of passing the `IsNull` method a field value to test, you pass it the column’s name, the column’s position, or an instance of the column.

```csharp
C#
if (oneRow.IsNull("Comments"))...

Visual Basic
If (oneRow.IsNull("Comments") = True)...``` 

**Note** `System.DBNull` is not the same as `null` in C#, or `Nothing` in Visual Basic. Those keywords indicate the absence of an object’s value. `System.DBNull.Value` is an object that presents a value.

**Storing Rows in a Table**

After you have assigned all required data values to the columns in a new row, add that row to the `DataTable` using the table’s `Rows.Add` method.

```csharp
C#
someTable.Rows.Add(oneRow);

Visual Basic
someTable.Rows.Add(oneRow)
```

An overload of the `Add` method lets you skip the formal row-object creation process; instead, you supply the final field values directly as arguments. All provided values must appear in the same order and position as the table’s `DataColumn` instances.
C#

// ----- Assumes column 0 is numeric, 1 is string.
someTable.Rows.Add(new Object[] {123, "Fred"});

Visual Basic

' ----- Assumes column 0 is numeric, 1 is string.
someTable.Rows.Add(123, "Fred");

Whichever method you employ, the Add process tests all data values to be added to the table for data type compliance before adding the row. If the new row contains any values that can't be stored in the target column-specific data type, the Add method throws an exception.

Adding Rows to a DataTable: C#

1. Open the “Chapter 3 CSharp” project from the installed samples folder. The project includes two Windows.Forms classes: AccountManager and AccountDetail.

2. Open the source code view for the AccountManager form. Locate the AccountManager_Load event handler. This routine creates a custom DataTable instance with five columns: ID (a read-only, auto-generated long integer), FullName (a required 30-character unique string), Active (a Boolean), AnnualFee (an optional decimal), and StartDate (an optional date).

3. Add the following statements just after the “Build some sample data rows” comment. These rows add new DataRow objects to the table using the Rows.Add alternative syntax:

```csharp
CustomerAccounts.Rows.Add(new Object[] {1L, "Blue Yonder Airlines", true, 500m, DateTime.Parse("1/1/2007")});
CustomerAccounts.Rows.Add(new Object[] {3L, "Wingtip Toys", false});
```

Adding Rows to a DataTable: Visual Basic

1. Open the “Chapter 3 VB” project from the installed samples folder. The project includes two Windows.Forms classes: AccountManager and AccountDetail.

2. Open the source code view for the AccountManager form. Locate the AccountManager_Load event handler. This routine creates a custom DataTable instance with five columns: ID (a read-only, auto-generated long integer), FullName (a required 30-character unique string), Active (a Boolean), AnnualFee (an optional decimal), and StartDate (an optional date).
3. Add the following statements just after the "Build some sample data rows" comment. These rows add new `DataRow` objects to the table using the `Rows.Add` alternative syntax:

```csharp
CustomerAccounts.Rows.Add({1&, "Blue Yonder Airlines", True, 500@, #1/1/2007#})
CustomerAccounts.Rows.Add({3&, "Wingtip Toys", False})
```

**Examining and Changing Data**

After adding a data row to a table, you can process it as a table member. For instance, you can iterate through the table’s `Rows` collection, examining the stored column values as you pass through each record. The following code adds up the sales tax for all records in the `allSales` table:

```csharp
decimal totalTax = 0m;
foreach (DataRow scanRow in someTable.Rows)
    if (!DBNull.Value.Equals(scanRow["SalesTax"]))
        totalTax += (decimal)scanRow["SalesTax"];  
```

**Visual Basic**

```vbnet
Dim totalTax As Decimal = 0@
For Each scanRow As DataRow In someTable.Rows
    If (IsDBNull(scanRow!SalesTax) = False) Then
        totalTax += CDec(scanRow!SalesTax)
    Next scanRow
```

Because each row’s collection of items is not strongly typed, you might need to cast or convert each field to the target data type before using it.

**Note** ADO.NET does include extension methods that provide strongly typed access to each row’s members. These methods were added to the system to support LINQ and its method of querying data within the context of the Visual Basic or C# language. Part IV of this book introduces LINQ and its use with ADO.NET data.

Because of this lack of strong typing, be careful when assigning new values to any row already included in a table. For example, code that assigns a string value to an integer column will compile without error, but will generate a runtime error.
**Modifying Existing Rows in a DataTable: C#**

**Note** This exercise uses the “Chapter 3 CSharp” sample project and continues the preceding exercise in this chapter.

1. Open the source code view for the `AccountDetail` form. Locate the `AccountDetail_Load` routine.

2. Add the following code, which fills in the form’s display fields with content from an existing `DataRow` instance:

   ```csharp
define AccountEntry != null
   { AccountID.Text = string.Format("{0:0}", AccountEntry["ID"]);
     ActiveAccount.Checked = (bool)AccountEntry["Active"];
     if (DBNull.Value.Equals(AccountEntry["FullName"]) == false)
       AccountName.Text = (string)AccountEntry["FullName"];
     if (DBNull.Value.Equals(AccountEntry["AnnualFee"]) == false)
       AnnualFee.Text = string.Format("{0:0.00}",
         (decimal)AccountEntry["AnnualFee"]);
     if (DBNull.Value.Equals(AccountEntry["StartDate"]) == false)
       StartDate.Text = string.Format("{0:d}",
         (DateTime)AccountEntry["StartDate"]);
   }
```

3. Locate the `ActOK_Click` routine. In the `Try` block, just after the “Save the changes in the record” comment, you’ll find the following code line:

   ```csharp
   workArea.BeginEdit();
   ``

   Just after that line, add the following code, which updates an existing `DataRow` instance with the user’s input:

   ```csharp
   workArea["Active"] = ActiveAccount.Checked;
   if (AccountName.Text.Trim().Length == 0)
     workArea["FullName"] = DBNull.Value;
   else
     workArea["FullName"] = AccountName.Text.Trim();
   if (AnnualFee.Text.Trim().Length == 0)
     workArea["AnnualFee"] = DBNull.Value;
   else
     workArea["AnnualFee"] = decimal.Parse(AnnualFee.Text);
   if (StartDate.Text.Trim().Length == 0)
     workArea["StartDate"] = DBNull.Value;
   else
     workArea["StartDate"] = DateTime.Parse(StartDate.Text);
   ```
Modifying Existing Rows in a `DataTable`: Visual Basic

**Note** This exercise uses the “Chapter 3 VB” sample project and continues the preceding exercise in this chapter.

1. Open the source code view for the `AccountDetail` form. Locate the `AccountDetail_Load` routine.

2. Add the following code, which fills in the form's display fields with content from an existing `DataRow` instance:

   ```vbnet
   If (AccountEntry IsNot Nothing) Then
   AccountID.Text = CStr(AccountEntry!ID)
   ActiveAccount.Checked = CBool(AccountEntry!Active)
   If (IsDBNull(AccountEntry!FullName) = False) Then
       AccountName.Text = CStr(AccountEntry!FullName)
   If (IsDBNull(AccountEntry!AnnualFee) = False) Then
       AnnualFee.Text = Format(CDec(AccountEntry!AnnualFee), "0.00")
   If (IsDBNull(AccountEntry!StartDate) = False) Then
       StartDate.Text = Format(CDate(AccountEntry!StartDate), "Short Date")
   End If
   End If
   
3. Locate the `ActOK_Click` routine. In the `Try` block, just after the “Save the changes in the record” comment, you’ll find the following code line:

   ```vbnet
   workArea.BeginEdit()
   
   Just after that line, add the following code, which updates an existing `DataRow` instance with the user’s input:

   ```vbnet
   workArea!Active = ActiveAccount.Checked
   If (AccountName.Text.Trim.Length = 0) _
       Then workArea!FullName = DBNull.Value _
   Else workArea!FullName = AccountName.Text.Trim
   If (AnnualFee.Text.Trim.Length = 0) _
       Then workArea!AnnualFee = DBNull.Value _
   Else workArea!AnnualFee = CDec(AnnualFee.Text)
   If (StartDate.Text.Trim.Length = 0) _
       Then workArea!StartDate = DBNull.Value _
   Else workArea!StartDate = CDate(StartDate.Text)
Removing Data

You remove `DataRow` objects from a table via the `DataTable.Rows` collection’s `Remove` and `RemoveAt` methods. The `Remove` method accepts an instance of a row that is currently in the table.

```csharp
DataRow oneRow = someTable.Rows[0];
someTable.Rows.Remove(oneRow);
```

```visualbasic
Dim oneRow As DataRow = someTable.Rows(0)
someTable.Rows.Remove(oneRow)
```

The `RemoveAt` method also removes a row, but you pass it the index position of the row to delete.

```csharp
someTable.Rows.RemoveAt(0);
```

```visualbasic
someTable.Rows.RemoveAt(0)
```

If you have an instance of a data row available, but you want to call the `RemoveAt` method, you can obtain the index of the row from the `Rows` collection’s `IndexOf` method.

```csharp
int rowPosition = someTable.Rows.IndexOf(oneRow);
```

```visualbasic
Dim rowPosition As Integer = someTable.Rows.IndexOf(oneRow)
```

You can put any row you remove from a table right back into the `Rows` collection by using the standard `DataTable.Rows.Add` method. Another `Rows` method, `InsertAt`, adds a `DataRow` object to a table, but lets you indicate the zero-based position of the newly added row. (The `Add` method always puts new rows at the end of the collection.) The following code inserts a row as the first item in the collection:

```csharp
someTable.Rows.InsertAt(oneRow, 0);
```

```visualbasic
someTable.Rows.InsertAt(oneRow, 0)
```
To remove all rows from a table at once, use the `DataTable.Rows` object’s `Clear` method.

```
C#
someTable.Rows.Clear();

Visual Basic
someTable.Rows.Clear()
```

As convenient as `Remove`, `RemoveAt`, and `Clear` are, they come with some negative side effects. Because they fully remove a row and all evidence that it ever existed, these methods prevent ADO.NET from performing certain actions, including managing record removes within an external database. The next section, “Batch Processing,” discusses a better method of removing data records from a `DataTable` instance.

**Batch Processing**

The features shown previously for adding, modifying, and removing data records within a `DataTable` all take immediate action on the content of the table. When you use the `Add` method to add a new row, it’s included immediately. Any field-level changes made within rows are stored and considered part of the record—assuming that no data-specific exceptions get thrown during the updates. After you remove a row from a table, the table acts as if it never existed.

Although this type of instant data gratification is nice when using a `DataTable` as a simple data store, sometimes it is preferable to postpone data changes or make several changes at once, especially when you need to verify that changes occurring across multiple rows are collectively valid.

ADO.NET includes table and row-level features that let you set up “proposed” changes to be accepted or rejected en masse. When you connect data tables to their external database counterparts in later chapters, ADO.NET uses these features to ensure that updates to both the local copy of the data and the remote database copy retain their integrity. You can also use them for your own purposes, however, to monitor changes to independent `DataTable` instances.

**Note** In reality, ADO.NET always uses these batch processing monitoring tools when changes are made to any rows in a table, even changes such as those in this chapter’s simple code samples. Fortunately, the Framework is designed so that you can safely ignore these monitoring features if you don’t need them.
To use the batch system, simply start making changes. When you are ready to save or reject all changes made within a `DataTable`, call the table's `AcceptChanges` method to commit and approve all pending changes, or call the `RejectChanges` method to discard all unsaved changes. Each `DataRow` in the table also includes these methods. You can call the row-level methods directly, but the table-level methods automatically trigger the identically named methods in each modified row.

```csharp
someTable.AcceptChanges();  // Commit all row changes
someTable.RejectChanges();  // Reject changes since last commit
```

### Row State

While making your row-level edits, ADO.NET keeps track of the original and proposed versions of all fields. It also monitors which rows have been added to or deleted from the table, and can revert to the original row values if necessary. The Framework accomplishes this by managing various state fields for each row. The main tracking field is the `DataRow.RowState` property, which uses the following enumerated values:

- **`DataRowState.Detached`**  
  The default state for any row that has not yet been added to a `DataTable`.

- **`DataRowState.Added`**  
  This is the state for rows added to a table when changes to the table have not yet been confirmed. If you use the `RejectChanges` method on the table, any added rows will be removed immediately.

- **`DataRowState.Unchanged`**  
  The default state for any row that already appears in a table, but has not been changed since the last call to `AcceptChanges`. New rows created with the `NewRow` method use this state.

- **`DataRowState.Deleted`**  
  Deleted rows aren’t actually removed from the table until you call `AcceptChanges`. Instead, they are marked for deletion with this state setting. See the following discussion for the difference between “deleted” and “removed” rows.

- **`DataRowState.Modified`**  
  Any row that has had its fields changed in any way is marked as modified.

Every time you add or modify a record, the data table updates the row state accordingly. However, removing records from a data table with the `Rows.Remove` and `Rows.RemoveAt` methods circumvents the row state tracking system, at least from the table’s point of view.
To enable ADO.NET batch processing support on deleted rows, use the `DataRow` object’s `Delete` method. This does not remove the row from the `DataTable.Rows` collection. Instead, it marks the row’s state as deleted. The next time you use the table or row `AcceptChanges` method to confirm all updates, the row will be removed permanently from the table.

If you want to use the batch processing features, or if your `DataTable` instances are associated with a database table, even if that table is temporarily disconnected, you need to use the row-specific `Delete` method instead of `Remove` and `RemoveAt`.

```csharp
someTable.Rows.Remove(oneRow); // Removes row immediately
oneRow.Delete();               // Marks row for removal during approval
```

```vbnet
someTable.Rows.Remove(oneRow) ' Removes row immediately
oneRow.Delete()               ' Marks row for removal during approval
```

If you retain a reference to a deleted row once it has been removed from the table, its `RowState` property will be set to `DataRowState.Detached`, just like a new row that has not yet been added to a table.

**Note** When working with `DataTable` instances that are connected to true database tables, ADO.NET will still allow you to use the `Remove` and `RemoveAt` methods. However, these methods will not remove the row from the database-side copy. They remove only the local `DataTable.Rows` copy of the row. You must use the row’s `Delete` method to ensure that the row gets removed from the database upon acceptance.

### Row Versions

When you make changes to data within a data table’s rows, ADO.NET keeps multiple copies of each changed value. Row version information applies to an entire row, even if only a single data column in the row has changed.

- **DataRowVersion.Original** The starting value of the field before it was changed (the value that was in effect after the most recent use of `AcceptChanges` occurred).
- **DataRowVersion.Proposed** The changed but unconfirmed field value. The `Proposed` version of a field doesn’t exist until you begin to make edits to the field or row. When changes are accepted, the proposed value becomes the actual (`Original`) value of the field.
- **DataRowVersion.Current**  For fields with pending edits, this version is the same as *Proposed*. For fields with confirmed changes, the *Current* version is the same as the *Original* version.

- **DataRowVersion.Default**  For rows attached to a *DataTable*, this version is the same as *Current*. For detached rows, *Default* is the same as *Proposed*. The *Default* version of a row is not necessarily the same as the default values that might appear in newly created rows.

Depending on the current state of a row, some of these row versions might not exist. To determine whether a row version does exist, use the *DataRow.HasVersion* method. The following code block uses the *HasVersion* method and a special overload of the *Item* method to access various row versions:

C#  
```csharp
if (oneRow.HasVersion(DataRowVersion.Proposed))
{
    if (oneRow.Item["Salary", DataRowVersion.Original] !=
        oneRow.Item["Salary", DataRowVersion.Proposed])
        MessageBox.Show("Proposed salary change.");
}
```

Visual Basic  
```vbnet
If (oneRow.HasVersion(DataRowVersion.Proposed) = True) Then
    If (oneRow.Item("Salary", DataRowVersion.Original) <>
        oneRow.Item("Salary", DataRowVersion.Proposed)) Then
        MessageBox.Show("Proposed salary change.");
End If
```

The default row version returned by the *Item* property is the *Current* version.

**Validating Changes**

As mentioned earlier in the “Storing Rows in a Table” section on page 40, attempting to store data of the incorrect data type in a column will throw an exception. However, this will not prevent a user from entering invalid values, such as entering 7,437 into a *System.Int32* column that stores a person’s age. Instead, you must add validation code to your data table to prevent such data range errors.
Exception-Based Errors

ADO.NET monitors some data errors on your behalf. These errors include the following:

- Assigning data of the wrong data type to a column value.
- Supplying string data to a column that exceeds the maximum length defined in the column’s `DataColumn.MaxLength` property.
- Attempting to store a NULL value in a primary key column.
- Adding a duplicate value in a column that has its `Unique` property set.
- Taking data actions that violate one of the table's custom constraints. Constraints are discussed in Chapter 5, “Bringing Related Data Together.”

When one of these data violations occurs, ADO.NET throws an exception in your code at the moment when the invalid assignment or data use happens. The following code block generates an exception because it attempts to assign a company name that is too long for a 20-character column:

```csharp
C#
DataColumn withRule = someTable.Columns.Add("FullName", typeof(string));
withRule.MaxLength = 20;
// ...later...
DataRow rowToUpdate = someTable.Rows[0];
rowToUpdate["FullName"] = "Graphic Design Institute"; // 24 characters
// ----- Exception occurs with this assignment

Visual Basic
Dim withRule As DataColumn = someTable.Columns.Add("FullName", GetType(String))
withRule.MaxLength = 20
' ...later...
Dim rowToUpdate As DataRow = someTable.Rows(0)
rowToUpdate("FullName") = "Graphic Design Institute" ' 24 characters
' ----- Exception occurs with this assignment
```

Naturally, you would want to enclose such assignments within exception handling blocks. However, there are times when adding this level of error monitoring around every field change is neither convenient nor feasible—not to mention the impact it has on performance when adding or updating large numbers of records. To simplify exception monitoring, the `DataRow` class includes the `BeginEdit` method. When used, any data checks normally done at assignment are postponed until you issue a matching `DataRow.EndEdit` call.
To roll back any changes made to a row since using `BeginEdit`, use the `CancelEdit` method. Even when you complete a row’s changes with the `EndEdit` method, the changes are not yet committed. It is still necessary to call the `AcceptChanges` method, either at the row or the table level.

The `DataTable.AcceptChanges` and `DataRow.AcceptChanges` methods, when used, automatically call `DataRow.EndEdit` on all rows with pending edits. Similarly, `DataTable.RejectChanges` and `DataRow.RejectChanges` automatically issue calls to `DataRow.CancelEdit` on all pending rows changes.

### Validation-Based Errors

For data issues not monitored by ADO.NET, including business rule violations, you must set up the validation code yourself. Also, you must manually monitor the data table for such errors and refuse to confirm changes that would violate the custom validation rules.

Validation occurs in the various event handlers for the `DataTable` instance that contains the rows to monitor. Validation of single-column changes typically occurs in the `ColumnChanging` event. For validation rules based on the interaction between multiple fields in a data row, use the `RowChanging` event. The `RowDeleting` and `TableNewRow` events are useful for checking data across multiple rows or the entire table. You can also use any of the other table-level events (`ColumnChanged, RowChanged, RowDeleted, TableClearing, TableCleared`) to execute validation code that meets your specific needs.

Inside the validation event handlers, use the `Proposed` version of a row value to assess its preconfirmed value. When errors occur, use the row’s `SetColumnError` method (with the name, position, or instance of the relevant column) to indicate the problem. For row-level errors, assign a description of the problem to the row’s `RowError` property. The following code applies a column-level business rule to a numeric field, setting a column error if there is a problem:
C#  
```c#  
private void Applicant_ColumnChanging(Object sender,  
    System.Data.DataColumnChangeEventArgs e)  
{  
    // ----- Check the Age column for a valid range.  
    if (e.Column.ColumnName == "Age")  
    {  
        if ((int)e.ProposedValue < 18 || (int)e.ProposedValue > 29)  
            e.Row.SetColumnError(e.Column,  
                "Applicant's age falls outside the allowed range.");  
    }  
}  
```

Visual Basic  
```vbnet  
Private Sub Applicant_ColumnChanging(ByVal sender As Object,  
    ByVal e As System.Data.DataColumnChangeEventArgs)  
' ----- Check the Age column for a valid range.  
If (e.Column.ColumnName = "Age") Then  
    If (CInt(e.ProposedValue) < 18) Or (CInt(e.ProposedValue) > 29) Then  
        e.Row.SetColumnError(e.Column,  
            "Applicant's age falls outside the allowed range.")  
    End If  
End If  
End Sub  
```

Adding column or row-level errors sets both the `DataRow.HasErrors` and the `DataTable.HasErrors` properties to `True`, but that’s not enough to trigger an exception. Instead, you need to monitor the `HasErrors` properties before confirming data to ensure that validation rules are properly applied. Another essential method, `ClearErrors`, removes any previous error notices from a row.

C#  
```c#  
// ----- Row-level monitoring.  
oneRow.ClearErrors();  
oneRow.BeginEdit();  
oneRow.FullName = "Tailspin Toys"; // Among other changes  
if (oneRow.HasErrors)  
{  
    ShowFirstRowError(oneRow);  
    oneRow.CancelEdit();  
}  
else  
    oneRow.EndEdit();  
// ----- Table-level monitoring. Perform row edits, then...  
if (someTable.HasErrors)  
{  
    DataRow[] errorRows = someTable.GetErrors();  
    ShowFirstRowError(errorRows[0]);  
    someTable.RejectChanges(); // Or, let user make additional corrections  
}  
```
else
    someTable.AcceptChanges();

// ...later...

public void ShowFirstRowError(DataRow whichRow)
{
    // ----- Show first row-level or column-level error.
    string errorText = "No error";
    DataColumn[] errorColumns = whichRow.GetColumnsInError();
    if (errorColumns.Count > 0)
        errorText = whichRow.GetColumnError(errorColumns[0]);
    else if (whichRow.RowError.Length > 0)
        errorText = whichRow.RowError;
    if (errorText.Length == 0) errorText = "No error";
    MessageBox.Show(errorText);
}

Visual Basic

' ----- Row-level monitoring.
oneRow.ClearErrors()
oneRow.BeginEdit()
oneRow.FullName = "Tailspin Toys" ' Among other changes
If (oneRow.HasErrors = True) Then
    ShowFirstRowError(oneRow)
oneRow.CancelEdit()
Else
    oneRow.EndEdit()
End If

' ----- Table-level monitoring. Perform row edits, then...
If (someTable.HasErrors = True) Then
    Dim errorRows() As DataRow = someTable.GetErrors()
    ShowFirstRowError(errorRows(0))
someTable.RejectChanges() ' Or, let user make additional corrections
Else
    someTable.AcceptChanges()
End If

' ...later...

Public Sub ShowFirstRowError(ByVal whichRow As DataRow)
' ----- Show first column-level or row-level error.
    Dim errorText As String = ""
    Dim errorColumns() As DataColumn = whichRow.GetColumnsInError()
    If (errorColumns.Count > 0) Then
        errorText = whichRow.GetColumnError(errorColumns(0))
    ElseIf (whichRow.RowError.Length > 0) Then
        errorText = whichRow.RowError
    End If
    If (errorText.Length = 0) Then errorText = "No error"
    MessageBox.Show(errorText)
End Sub
Validating Content in a **DataRow**: C#  

**Note** This exercise uses the “Chapter 3 CSharp” sample project and continues the preceding exercise in this chapter.

1. Open the source code view for the `AccountManager` form.

2. Locate the `CustomerAccounts_ColumnChanging` event handler, which is called whenever a column value in a `CustomerAccounts` table row changes. Add the following code, which checks for valid data in two of the columns:

   ```csharp
   if (e.Column.ColumnName == "AnnualFee")
   {
       // ----- Annual fee may not be negative.
       if (DBNull.Value.Equals(e.ProposedValue) == false)
       {
           if ((decimal)e.ProposedValue < 0m)
           {
               e.Row.SetColumnError(e.Column, "Annual fee may not be negative.");
           }
       }
   }
   else if (e.Column.ColumnName == "StartDate")
   {
       // ----- Start date must be on or before today.
       if (DBNull.Value.Equals(e.ProposedValue) == false)
       {
           if (((DateTime)e.ProposedValue).Date > DateTime.Today)
           {
               e.Row.SetColumnError(e.Column, "Start date must occur on or before today.");
           }
       }
   }
   
3. Locate the `CustomerAccounts_RowChanging` event handler, which is called whenever any value in a row changes within the `CustomerAccounts` table. Add the following code, which checks for valid data involving multiple columns:

   ```csharp
   if (e.Row.HasVersion(DataRowVersion.Proposed) == true)
   {
       if (((bool)e.Row["Active", DataRowVersion.Proposed] == true) &&
           (DBNull.Value.Equals(e.Row["StartDate",
            DataRowVersion.Proposed]) == true))
       {
           e.Row.RowError = "Active accounts must have a valid start date.";
       }
   }
   ```
4. Run the program. Use its features to create, edit, and delete data rows. When you attempt to provide invalid data—incorrect data types, violations of business rules, duplicate account names—the program provides the appropriate error messages.

![Image of Account Manager form]

**Validating Content in a **DataRow**: Visual Basic**

**Note** This exercise uses the “Chapter 3 VB” sample project and continues the preceding exercise in this chapter.

1. Open the source code view for the **AccountManager** form.

2. Locate the **CustomerAccounts_ColumnChanging** event handler, which is called whenever a column value in a **CustomerAccounts** table row changes. Add the following code, which checks for valid data in two of the columns:

```vbnet
If (e.Column.ColumnName = "AnnualFee") Then
    ' ----- Annual fee may not be negative.
    If (IsDBNull(e.ProposedValue) = False) Then
        If (CDec(e.ProposedValue) < 0) Then
            e.Row.SetColumnError(e.Column,
            "Annual fee may not be negative.")
        End If
    End If
ElseIf (e.Column.ColumnName = "StartDate") Then
    ' ----- Start date must be on or before today.
    If (IsDBNull(e.ProposedValue) = False) Then
        If (CDate(e.ProposedValue).Date > Today) Then
            e.Row.SetColumnError(e.Column,
            "Start date must occur on or before today.")
        End If
    End If
End If
```
3. Locate the `CustomerAccounts_RowChanging` event handler, which is called whenever any value in a row changes within the `CustomerAccounts` table. Add the following code, which checks for valid data involving multiple columns:

```csharp
If (e.Row.HasVersion(DataRowVersion.Proposed) = True) Then
    If (CBool(e.Row("Active", DataRowVersion.Proposed)) = True) And
    (IsDBNull(e.Row("StartDate", DataRowVersion.Proposed)) = True) Then
        e.Row.RowError = "Active accounts must have a valid start date."
    End If
End If
```

4. Run the program. Use its features to create, edit, and delete data rows. When you attempt to provide invalid data—incorrect data types, violations of business rules, duplicate account names—the program provides the appropriate error messages.

**Summary**

This chapter discussed the `DataRow` class, the final destination of all data in ADO.NET. With one instance created per data record, the `DataRow` class manages each individual columnar field. When used alone, its stored values use the generic `Object` data type, but when inserted into a `DataTable` object's `Rows` collection, all data type limitations and other constraints established for the table's columns act together to verify the row's content.

Beyond these column settings, you can add event handlers to the `DataTable` that apply custom business rules to the column and row data, providing an additional layer of validation—and ultimately, integrity—for the table's data.
## Chapter 3 Quick Reference

<table>
<thead>
<tr>
<th>To</th>
<th>Do This</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add a row to a <code>DataTable</code></td>
<td>Use the <code>DataTable</code> object’s <code>NewRow</code> method to obtain a <code>DataRow</code> instance. Update the <code>Item</code> values in the <code>DataRow</code> as needed. Add the row using the table’s <code>Rows.Add</code> method.</td>
</tr>
<tr>
<td>Delete a row from a <code>DataTable</code></td>
<td>Call the <code>DataRow</code> object’s <code>Delete</code> method. Call the <code>DataTable</code> object’s <code>AcceptChanges</code> method.</td>
</tr>
<tr>
<td>Check for data issues in new and modified <code>DataRow</code> objects</td>
<td>Create a <code>DataTable</code>. Add <code>DataColumn</code> definitions as needed. Add event handlers for the <code>DataTable</code> object’s <code>ColumnChanging</code>, <code>RowChanging</code>, or other events. In the handlers, call the <code>DataRow</code> object’s <code>SetColumnError</code> method or update its <code>RowError</code> property.</td>
</tr>
<tr>
<td>Temporarily suspend data validation while modifying a data row</td>
<td>Call the <code>DataRow</code> object’s <code>BeginEdit</code> method. Update the <code>Item</code> values in the <code>DataRow</code> as needed. Call the <code>DataRow</code> object’s <code>EndEdit</code> method.</td>
</tr>
</tbody>
</table>
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